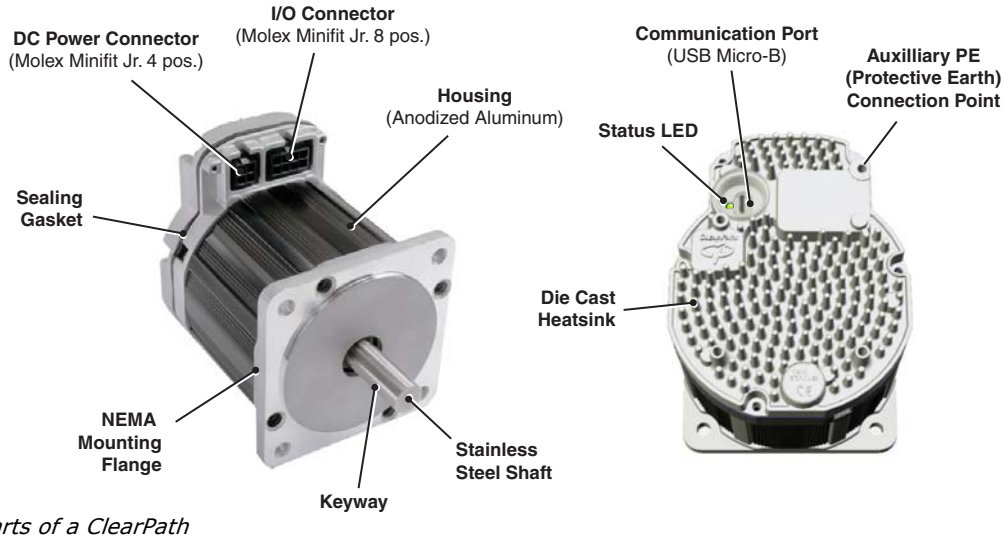
ClearPath Quick Start Guide

Read this to get your ClearPath Motor running in minutes!

Introduction

Thank you for choosing a ClearPath all-in-one servo system. We know that when most people get a new tech product, they want to try it out right away. For that reason ClearPath is ready to go right out of the box. Your ClearPath motor was shipped to you fully tested and factory preconfigured for unloaded use (i.e. with nothing attached to the shaft). This means you can power it up, connect to your PC, and start making test moves within minutes. And, when you're ready to connect ClearPath to a mechanical system, you'll have the world's most advanced Auto-tuning software to help. Use this Quick Start Guide to get up and running quickly, but refer to the ClearPath User Manual for complete details on safety, installation, and operation.



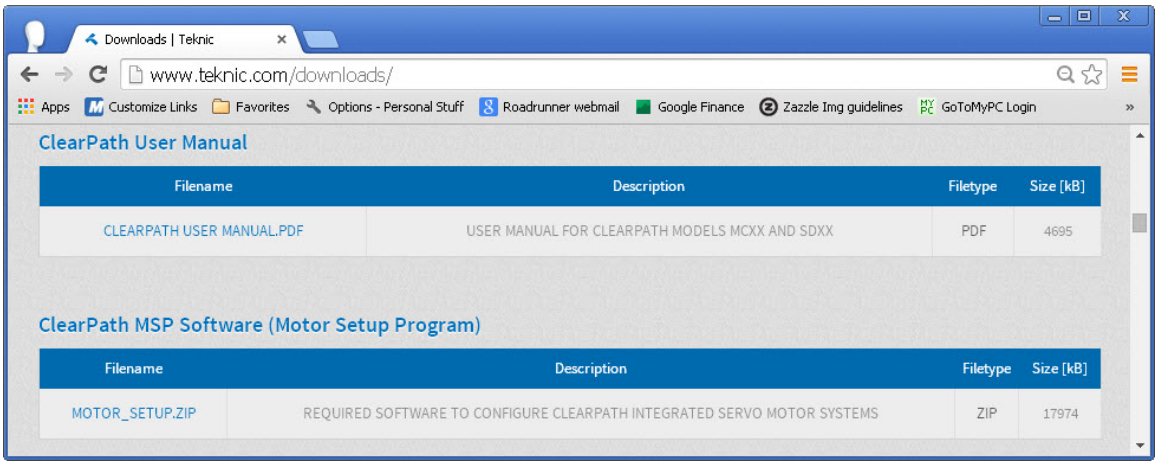
Parts of a ClearPath

READ THIS IMPORTANT WARNING!

Always use caution and common sense when handling motion control equipment. Even the smallest ClearPath Motor is powerful enough to mangle fingers, turn a tie into a noose, or tear out a patch of hair in less than 20 milliseconds (by comparison, it takes about 100 milliseconds to blink!) We're not trying to scare you—well, maybe a little—but we want all ClearPath users to stay safe *and intact*. These devices are extremely powerful and **dangerous if used carelessly**. Please read and understand all safety warnings in the ClearPath User Manual before operating a ClearPath Motor.

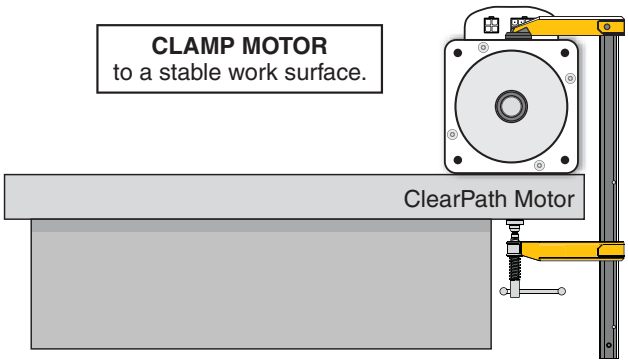
Initial Setup

Download and install ClearPath MSP (**M**otor **S**etup **P**rogram) from the Teknic website: http://www.teknic.com/downloads. MSP is compatible with Windows 8,7,XP and Vista.



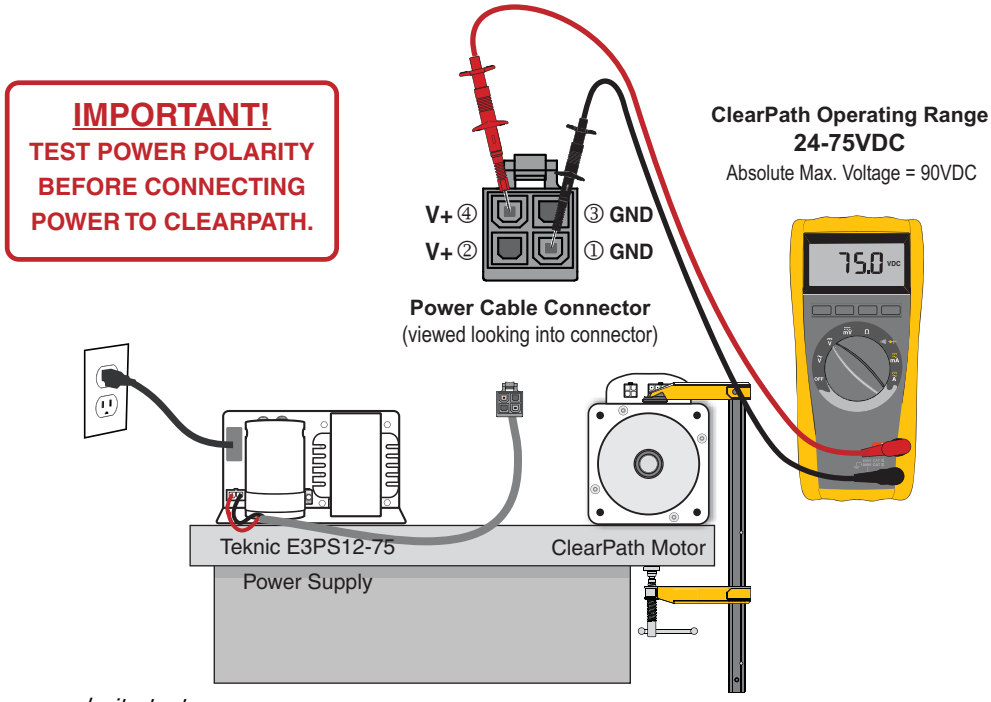
Teknic website: Downloads page

Secure your ClearPath to a stable work surface. A "Quick-Grip" style bar clamp or bench vise will do the job nicely. Tip: You can help preserve your motor's finish by covering the vise jaws with tape, cardboard or similar.



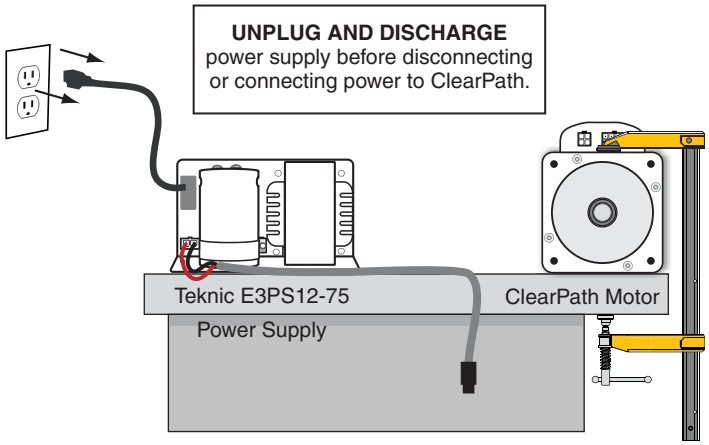
Clamp it!

IMPORTANT! Check voltage polarity at the power cable connector. Reversing voltage polarity (swapping positive and negative leads) will damage your ClearPath and void the warranty. Teknic power supplies and cables are pre-tested for proper polarity. Never wire AC (wall current) directly to a ClearPath.



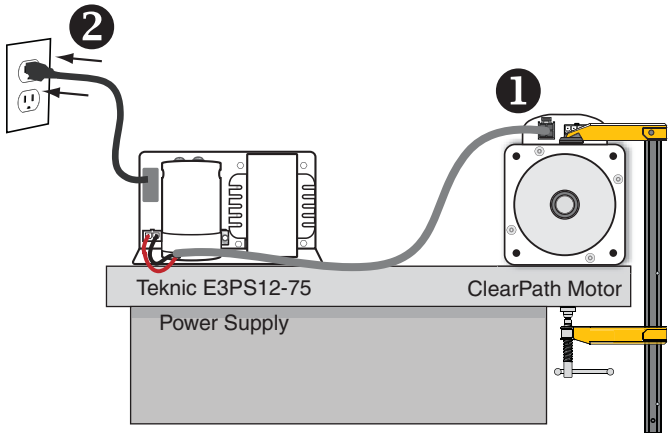
Basic power polarity test

Start with power supply unplugged and discharged. This will prevent electrical arcing from damaging your ClearPath power terminals over time. Always turn off and discharge your power supply before connecting or disconnecting the power cable from a ClearPath. If you hear an electrical "snap" when you plug in the power connector, you did it wrong.



Unplug and discharge the power supply before connecting it to your ClearPath

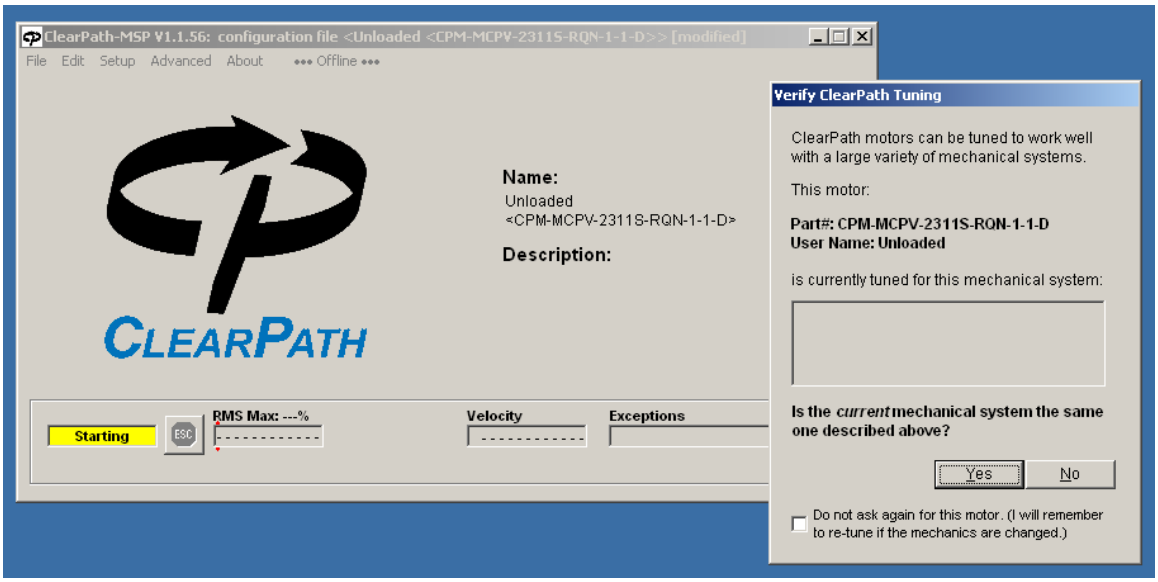
Plug the power cable into the ClearPath power connector (1).
Plug in and turn on the power supply (2). The status LED at rear of ClearPath should be on and solid yellow.



Powering up your ClearPath

Connect the USB cable from ClearPath to your PC. For first-time connections, wait for ClearPath to auto-install its drivers before proceeding. This should take less than a minute.

Run MSP software. After you launch MSP, ClearPath will establish USB communication with your PC. MSP will then identify your ClearPath Motor by model. You'll see a windows layout that looks similar to the one shown below. Click "Yes" in the dialog box to continue.



Launching ClearPath MSP

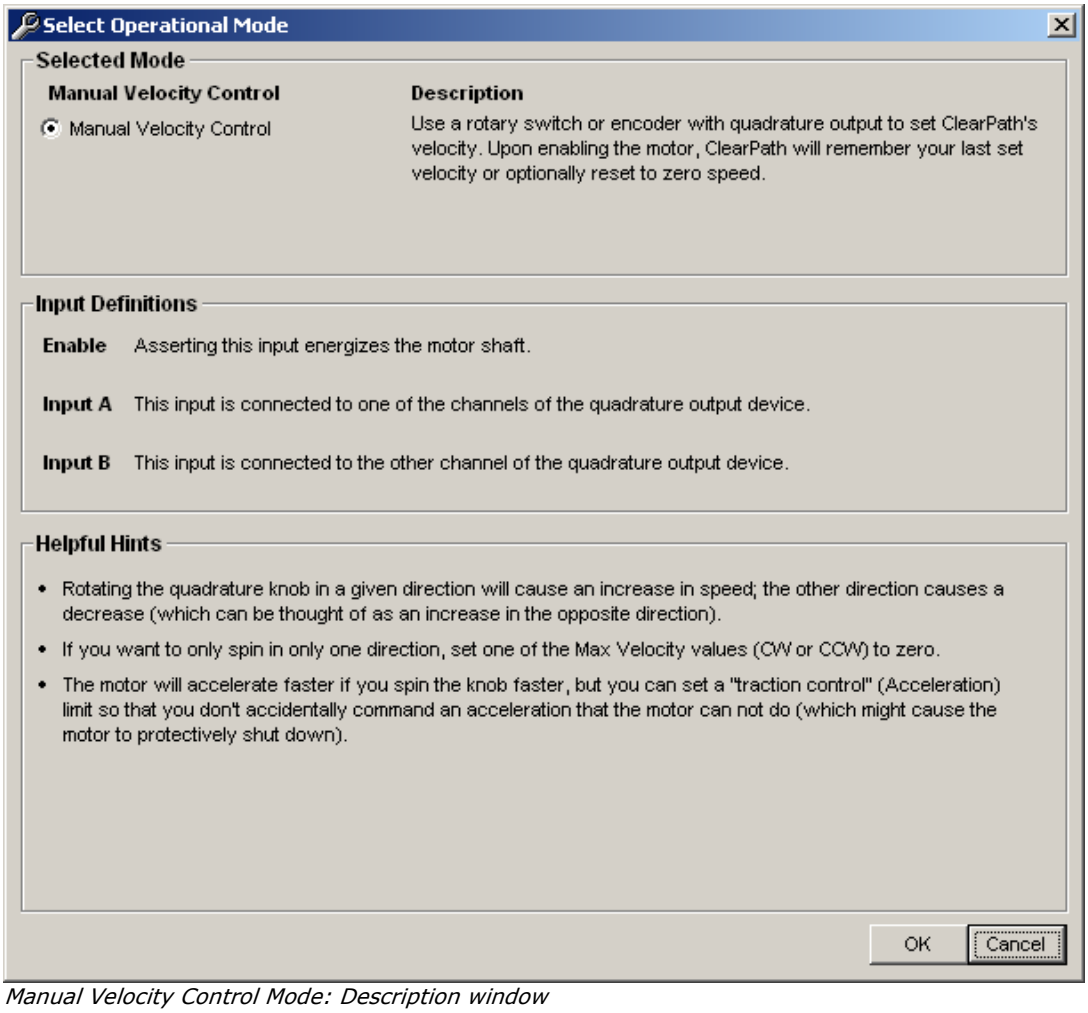
Running ClearPath under software control

Before wiring switches, sensors, outputs or mechanical components to your ClearPath, try running ClearPath unloaded, using only the MSP software controls. This will help you get acquainted with the MSP user interface and some of the different operational modes with no additional wiring involved.

Note: Software control is not meant for use in your finished machine. It is intended for test, experimentation or just playing around to learn how ClearPath and MSP work.

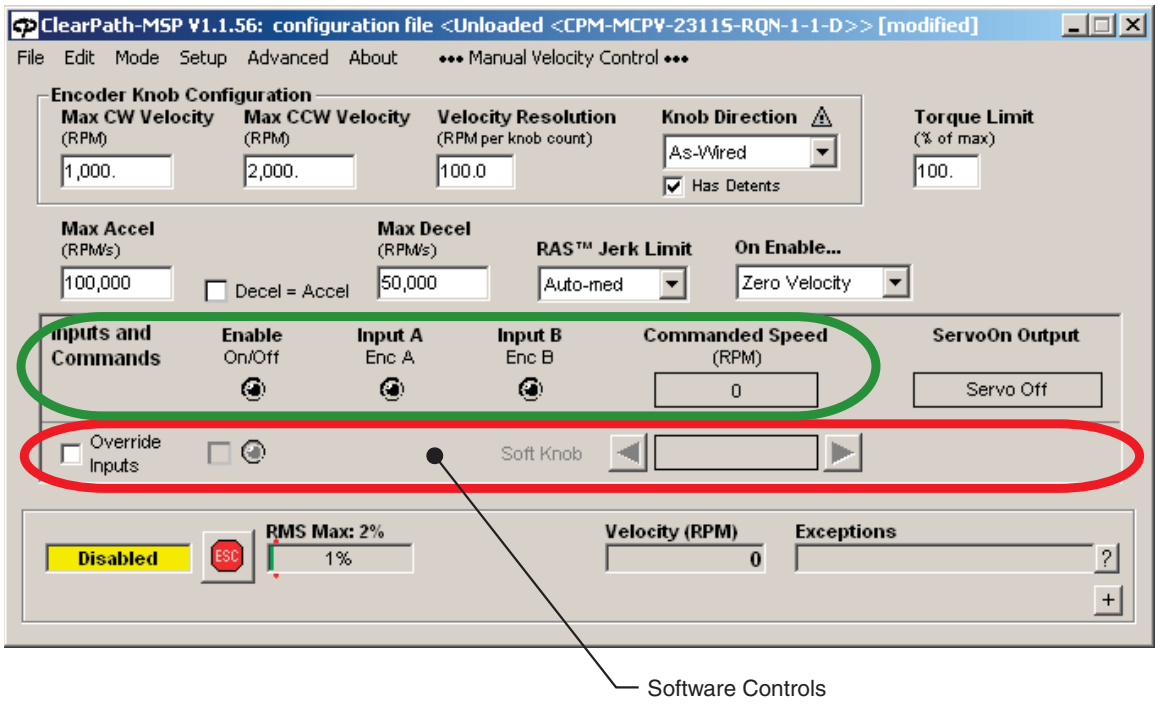
In this section we'll discuss some of the basics of ClearPath Software Control. For this example we'll be using **Manual Velocity Mode** (available on MCPV and MCVC models).

Start Manual Velocity Mode. On MSP's main menu, go to **Mode>Manual Velocity Mode**. Whenever you select a new mode, you'll see an informative popup window such as the one shown below. *Read everything in the window if you're not familiar with the mode*. It will save you time and trouble as you learn how to use the mode. After reading the window text, click OK to proceed.



Manual Velocity Control Mode: Description window

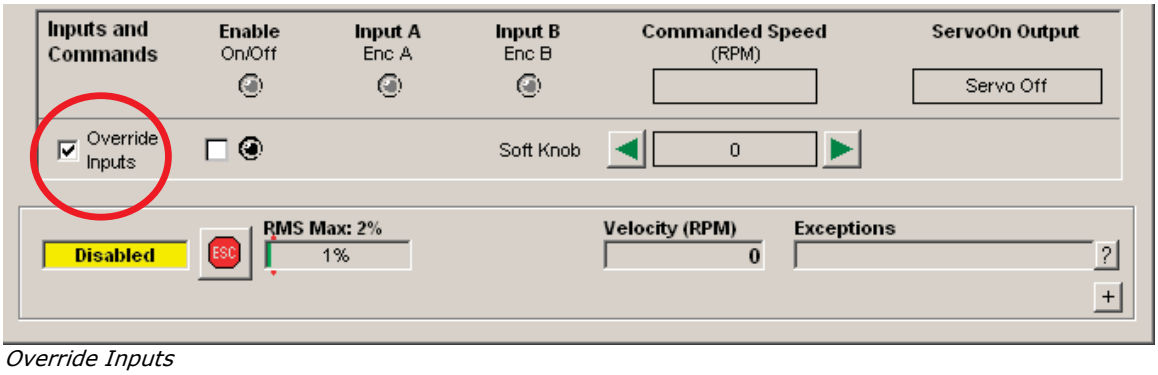
After reading the Mode Description (previous figure) you know that this mode requires a quadrature output device wired to Inputs A and B. We're going to skip the hardware and use only the soft controls to emulate the behavior of a quadrature output device. This way we can see how the mode works without spending any extra time, effort or money.



Manual Velocity Control Mode: Setup Window

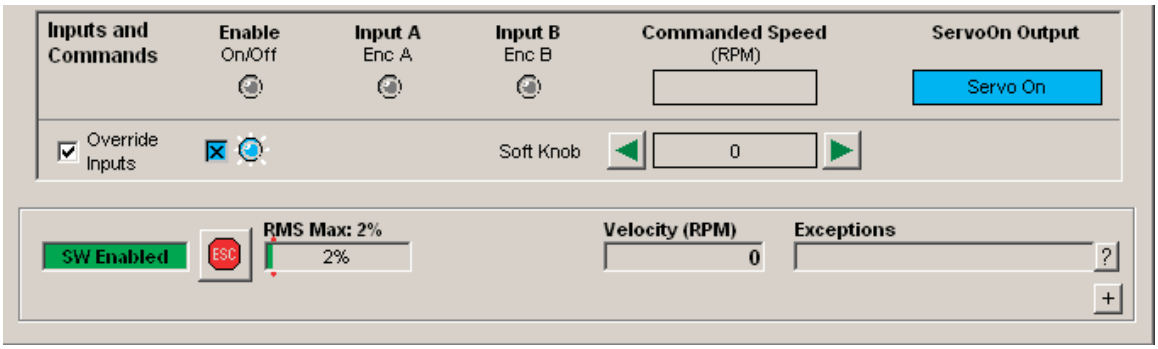
Enter your motion parameters. For now just enter the settings as they appear above. Many of these parameters are self-explanatory, but some may require further explanation. We'll cover the important ones in a minute. See the ClearPath User Manual for a detailed explanation of each setting. The Software Controls are circled in red; the Hardware Indicators are circled in green.

Check the "Override Inputs" box. This overrides the hardware inputs and turns on Software Controls. Notice that the Enable control box is no longer grayed out, while the Hardware Indicator LEDs now *are* grayed out. Also, the "Soft Knob" controls are green and ready for use. You are just about ready to command motion.



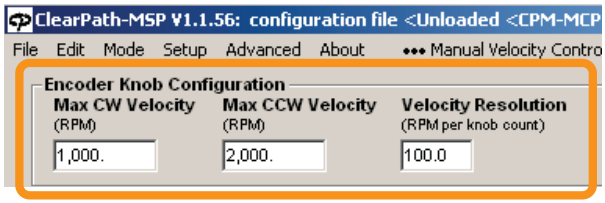
Override Inputs

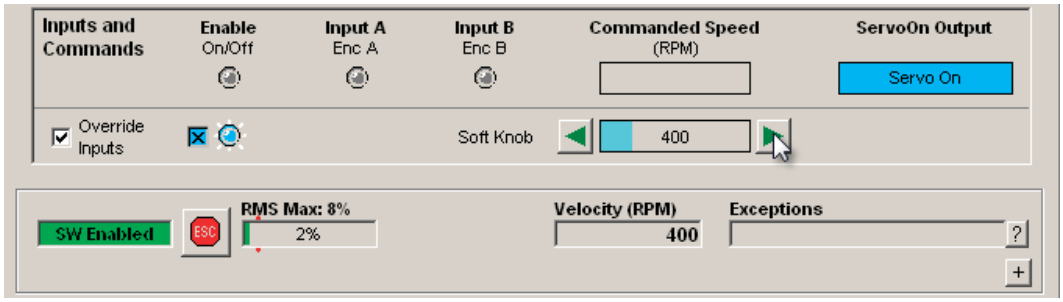
Enable the motor. Click the Enable box to enable the motor. When enabled, the motor windings are energized. The shaft will hold position and the Status Box (lower left of figure below) will turn green with the words "SW Enabled" (Software Enabled). Click again to disable. Disabling removes power from the motor coils.



Enabling ClearPath using Software Controls

Spin the motor. Click the right arrow on the Soft Knob control to spin counter-clockwise. Each click increases motor speed by 100 RPM based on the Velocity Resolution setting. Click the left arrow and motor speed will decrease by 100 RPM (technically it's increasing speed in the opposite direction) until you're back to zero speed. Keep clicking the left arrow and the motor shaft will soon be spinning clockwise, increasing in speed by 100 RPM per click. Look at the Velocity Display to see how fast you're spinning at any time.





Setting	Means
Max CW Velocity=1000 RPM	The motor is limited to 1000 RPM in the clockwise direction.
Max CCW Velocity=2000 RPM	The motor is limited to 2000 RPM in the counter-clockwise direction.
Velocity Resolution=100 RPM per click	Each click of the "Soft Knob" will cause a speed increase or decrease of 100 RPM.

Tip: If you only want ClearPath to spin clockwise, set "Max CCW Velocity" to zero.

A few things you should know when operating your ClearPath:

- If you see a small "warning triangle" appear anywhere in the Mode Controls section, hover your cursor over it and read the associated warning that pops up (it's like a tool tip).
- If you exceed your power supply's capability ClearPath will tell you. You'll see warnings or shutdowns in the Exceptions field at lower right of the UI. (THIS IS OK!) Try lowering your acceleration and/or velocity until the warning stops.
- Most shutdowns are caused by wimpy power supplies, mechanical problems or bad settings. If your ClearPath goes into shutdown it is probably just reporting a problem, but is probably not the cause of the problem.
- You can clear most shutdowns by toggling the Enable Input; however if you don't correct the underlying problem, you'll most likely keep getting shutdowns.
- IF THE STATUS LED FLASHES RED, there's a real problem with your ClearPath. Seek support assistance.

Wiring Inputs and Output (switches, sensors, PLCs, etc.)

ClearPath has three inputs and one output. Wiring I/O devices to your ClearPath is beyond the scope of this document. Please refer to the ClearPath User Manual for I/O wiring information and specifications.

Connecting ClearPath to mechanical components

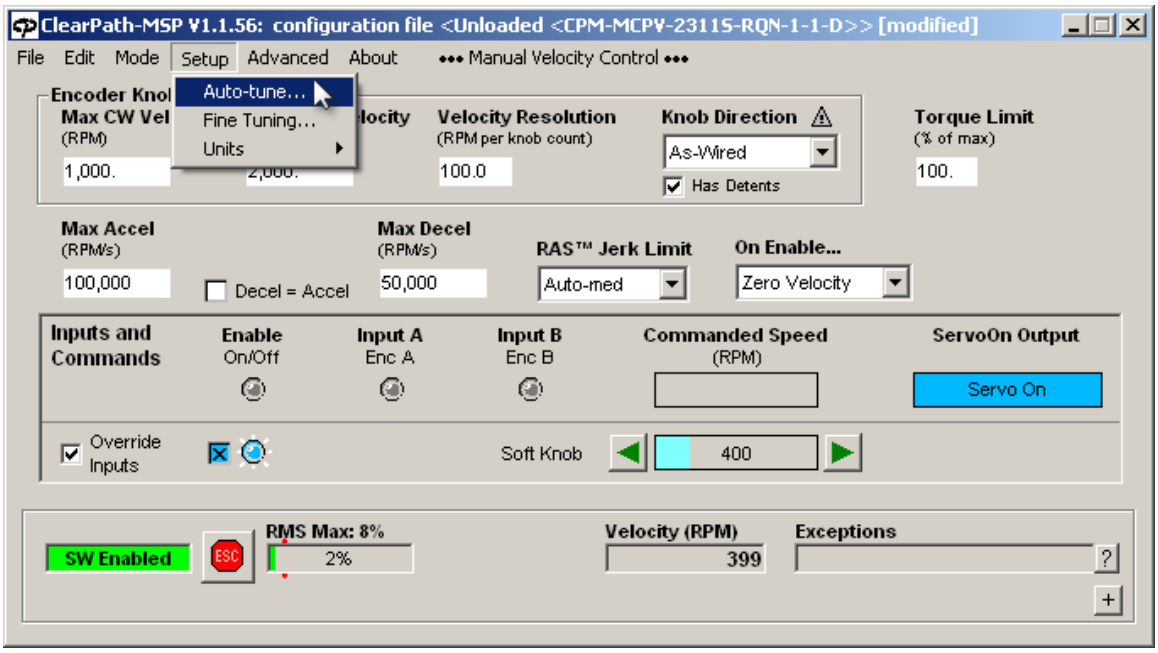
- Don't pound or pry the motor shaft.
- If connecting ClearPath to a screw, carefully align the rotating centers of the motor shaft and screw.
- Avoid solid couplings; they are very unforgiving of misalignment.
- Avoid set screws. They don't hold well and tend to damage and deform the motor shaft. Use circumferential couplings instead.
- Tighten all fasteners before operating or tuning (couplings, mounting screws, pinions, pulleys). You don't want parts flying around at high speed.
- See the ClearPath User Manual for more tips on connecting ClearPath to mechanical components.

Auto-tuning your system

Before you begin the Auto-tune process:

- Disable your ClearPath.
- Tighten all couplings, screws, bolts, etc.
- Make sure the axis or machine frame is fully intact.
- Don’t try to tune a system on wheels or on a flimsy card table.
- Use a beefy “bulk” linear power supply with a decent capacitor bank and peak current capability such as Teknic model E3PS12-75.
- Don’t use a switching power supply. Most switching supplies do not have the peak current, capacitance and regenerated energy management required by high performance servo systems.

Start the Auto-tuner by selecting Setup>Auto-tune from the main menu



Starting Auto-tune

IMPORTANT! Read and follow all on screen directions to the letter.
The Auto-tune application will walk you through the process in a step-by-step manner. Read every word on every window. ***This is not the time to skim!*** Each Auto-tune session is different, but certain principles apply to all:

- Be careful. Keep your hands, hair and clothing away from the motor shaft
- Be patient. Auto-tune can take up to 30 minutes (more typically 5-15 minutes).
- Expect to hear humming, buzzing, clicks and clacks. Loud squeals and buzzes are not uncommon and perfectly normal. ClearPath is exploring the limits of the system.

Before you seek technical assistance, please read this:

I see no status LED, and (apparently) have no power.

- Plug in and turn on power supply.
- Connect power cable to ClearPath.
- Check power supply fuse.
- Verify wall outlet is powered. If not, reset breaker.
- Was the power wiring reversed at some point? If so, you're ClearPath is probably damaged and requires repair.

I see the status LED, but there is no communication between ClearPath and my PC.

- Disconnect the USB cable from both sides, close MSP, restart MSP, and reconnect the USB cable.
- Are you using a USB 3.0 port? Try a USB 2.0 port or a USB 2.0 hub plugged into a USB 3.0 port. ClearPath is compatible with fully compliant USB 3.0 ports, however there are known issues with the USB 3.0 ports made by certain manufacturers.

Everything was working fine, but Auto-tune failed to complete.

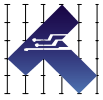
- Make sure there's only one version of MSP installed on your computer.
- If your power supply is a switcher or an underpowered "bulk" linear supply with insufficient current and/or capacitance, and cannot tolerate regenerated energy, you'll have problems running Auto-tune. ClearPaths can run between 24 and 75 VDC, but require adequate power to do so. Try a beefier supply.

I'm getting shutdowns.

- A shutdown seldom means your ClearPath is broken or defective.
- Shutdowns with yellow or green blink codes usually mean that ClearPath is *reporting* a problem, but it is unlikely to *be* the problem. Connect ClearPath to your PC running MSP and look in the "Exceptions" field to see what's being reported.
- Check the ClearPath User Manual (Appendix A) for blink code details, clues, and possible fixes.
- Any Shutdown accompanied by a red flashing LED is bad news. If you see this, and cannot clear it, you'll probably have to return your ClearPath for repair or replacement.

How do I reset my ClearPath to factory default settings?

If you need to return ClearPath to its original (shipped to you) state, use *File>Reset Config File To Factory Defaults*. All parameters and settings will be over-written and ClearPath will be returned to the default factory configuration.



USER MANUAL

CLEARPATH MOTORS

CLEARPATH MODELS MCXX AND SDXX

VERSION 1.84 AUGUST 1, 2014

TEKNIC, INC FAX (585)784-7460 VOICE (585)784-7454

THIS PAGE INTENTIONALLY LEFT BLANK

TABLE OF CONTENTS

SAFETY WARNINGS

IMPORTANT: Read this manual before attempting to install, apply power to, or operate a ClearPath motor. Failure to understand and follow the safety information presented in this document could result in property damage, bodily injury or worse.

SAFETY WARNINGS

- Do not wear loose clothing or unconfined long hair when using ClearPath motors. Remove ties, rings, watches and other jewelry before operating an unguarded motor.
- Do not operate a ClearPath if your alertness, cognitive function, or motor skills are impaired.
- Always handle, and carry a ClearPath motor by the housing (don't carry it by the shaft or any connected cable). Be aware that in certain modes of operation ClearPath is designed to spin as soon as main DC power is applied.
- Always understand how to use a mode of operation and its associated controls before attempting to power, enable, or otherwise operate a ClearPath motor.
- Install and test all emergency stop devices and controls before using ClearPath.
- Before applying DC power, secure the ClearPath motor to a stable, solid work surface and install a finger-safe guard or barrier between the user and the motor shaft.
- Provide appropriate space around the motor for ventilation and cable clearances.
- Do not allow cables or other loose items to drape over, or rest near the motor shaft.
- Never place fingers, hands, or other body parts on or near a powered ClearPath.
- Thoroughly test all ClearPath applications at low speed to ensure the motor, controls, and safety equipment operate as expected.

DISCLAIMER

The Purchaser is responsible for determining the suitability of products for their different applications. The Purchaser must ensure that Seller's products are installed and utilized in accordance with all local, state, federal and private governing bodies and meet all applicable health and safety standards.

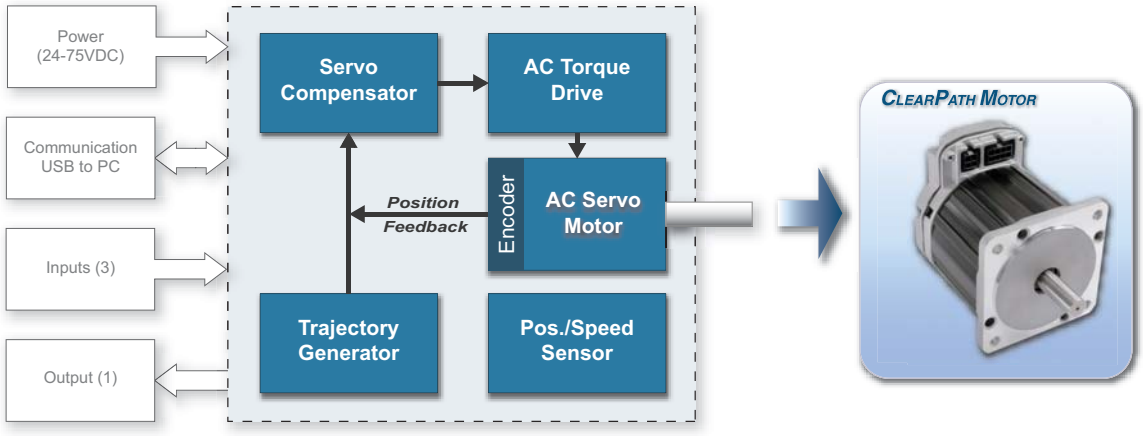
Seller has made all reasonable efforts to accurately present the information in the published documentation and shall not be responsible for any incorrect information which may result from unintentional oversights. Due to continuous product improvements, the product specifications as stated in the documentation are subject to change at any time and without notice. The Purchaser is responsible for consulting a representative of Seller for detailed information and to determine any changes of information in the published documentation.

Should Seller's products be used in an application that is safety critical, the Purchaser must provide appropriate safety testing of the products along with providing adequate safety devices, guarding, warning notices and provide machine specific training to protect the operator from injury.

INTRODUCTION

WHAT IS A CLEARPATH?

ClearPath is an all-in-one servo system: a precision brushless servo motor (with encoder) combined with a powerful integrated servo drive, trajectory generator, and internal controller, in a package about the size of a servo motor alone. ClearPath brings affordable, user-friendly, precision motion control to everyone from the OEM machine builder and shop automation specialist, to the educator, artist, and maker.



ClearPath functional blocks

ClearPath is a professional level, industrial grade product. The motor is based on Teknic's Hudson family of brushless servo motors, with the same instrument grade bearings, stainless steel shaft, windings, magnets, and encoder technology. The miniaturized motion control electronics and firmware employ the same field-proven technology and advanced motion control algorithms used by our OEM customers in automated machines in service around the world.

ClearPath Simplicity begins with a quick, uncomplicated setup. Install the included MSP software, connect ClearPath to your PC via USB, and configure and tune your ClearPath. Once setup is complete, disconnect ClearPath from your PC and start moving. With just three inputs and one output, sending commands and receiving feedback is simple and intuitive.

ClearPath MSP software is written in plain English with plenty of tips and annotations. Use MSP to select a mode of operation, set your move parameters and options (distance, speed, acceleration, torque) and tune the system. There's no steep learning curve with ClearPath.

Flexibility is evident in the many operating modes available. ClearPath motors can do:

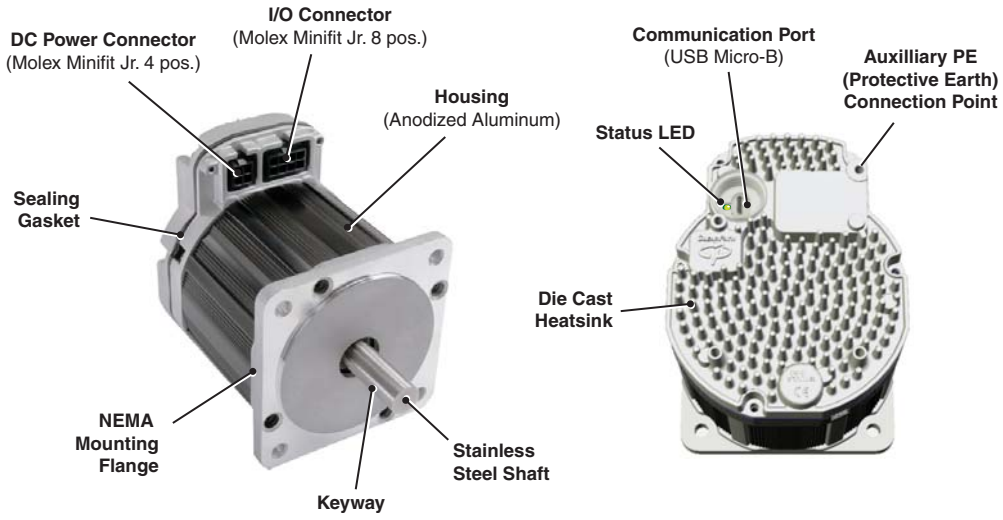
- Point-to-Point Positioning (move and settle with precision).
- Velocity Moves (spin at constant rotational speeds).
- Torque Moves (precisely control torque at the shaft).
- Stepper Emulation (use standard step-and-direction signals).

ClearPath motors are at home in applications ranging from variable speed conveyors to multi-axis positioning robots, to kinetic sculptures. And, while most ClearPath customers have a specific application in mind, it's nice to know that your ClearPath can be reprogrammed to perform a different job in minutes.

Safety and self-protection features are standard. ClearPath will rapidly shut down if it becomes overloaded, overheated, detects a hard stop, or exceeds any of the safety or motion limits you specify.

Made in USA. Each ClearPath motor is built and tested in our upstate New York manufacturing facility, so you can be certain you're getting a high quality, fully tested motion control product right out of the box. Additionally, Teknic backs up each ClearPath motor with a generous three year warranty.

PARTS OF A CLEARPATH



ClearPath Motor

DC Power Connector - Apply main DC power (24-75VDC) to this 4-position Molex MiniFit Jr. connector.

I/O connector - Access ClearPath's three inputs and one output through this 8-position Molex MiniFit Jr. connector.

USB Communication Port - Use this port to connect ClearPath to a Windows PC with a standard USB (Type A to Micro-B) cable.

Status LED - Tri-color LED Indicates operational status of ClearPath device. See appendix for key to LED codes.

Auxiliary PE (Protective Earth) Connection Point - Connect a wire between this unthreaded screw boss and your machine chassis to ensure proper motor grounding. This feature is typically used only if the motor mount itself is not bonded to the machine's PE terminal.

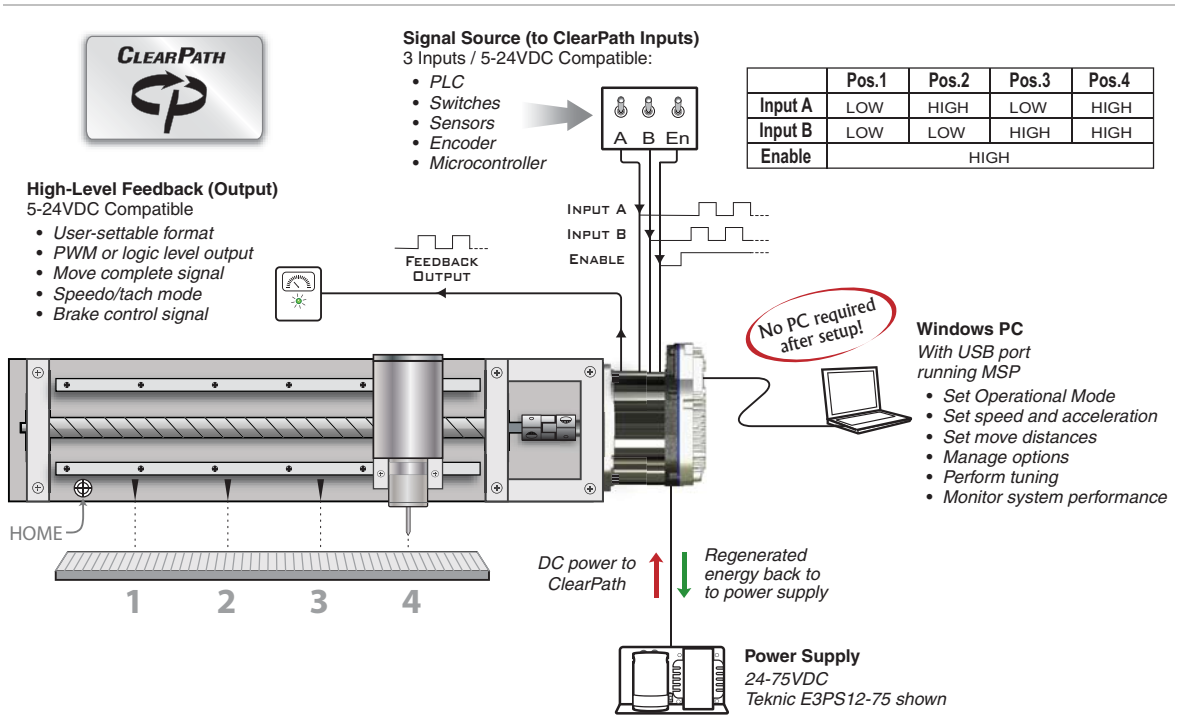
EXAMPLE APPLICATION: ABSOLUTE POSITIONING MODE

Read this section for a brief introduction to ClearPath technology and terminology through an example application, or visit www.teknic.com to view the complete series of ClearPath demonstration videos.

SUMMARY OF OPERATION

This section describes only one example application in one mode of operation. Absolute Positioning (4-position) mode allows you to define up to four target positions and command moves between any of them by changing the logical states of the ClearPath inputs.

In the figure below, a ClearPath model MCPV is coupled to a ball screw positioning stage. For now, we'll say that ClearPath has already been configured and programmed via the included MSP software. This just means that the mode of operation, target positions, velocity, acceleration, and options are already stored in ClearPath memory and the motor is ready to go. We'll discuss ClearPath configuration and setup a bit later in this section.



ClearPath Absolute Positioning (4-Position) Mode

Getting started. To energize/enable the motor, simply apply a DC voltage to the Enable input. Once enabled, the motor is considered "live", i.e. the motor is energized and will execute moves in response to state changes at Inputs A and B.

Caution: Depending on mode and settings selected, ClearPath can automatically move upon enable *with no user changes to the inputs*.

In this particular mode, ClearPath must home itself to establish an absolute reference position. The user's target positions are defined in terms of distance from the "home" position.

After homing is complete, ClearPath can be commanded to move to any of the predefined positions by changing the state of Inputs A and B (see table of Inputs in previous figure).

EXAMPLE: MAKING A MOVE

Motion objective: Move the load platform from position#1 to position #4.

User action: Simultaneously set Inputs A and B high. This can be done with toggle switches, PLC, microcontroller, or other suitable switching devices.

Motion result: The motor immediately executes a smooth, crisp move per the user's acceleration and velocity settings. The motor decelerates and settles at position #4. Note: ClearPath will actively servo to maintain position until another move command is received, unless the system is intentionally disabled, powered down, or in a shutdown state.

The Digital Output (we call it HLFB, for High-Level Feedback) can be configured to signal when ClearPath completes a move, reaches a specified speed or torque, or has shut itself down for safety reasons. See the section on High-Level Feedback for complete details.

OVERVIEW: CONFIGURING CLEARPATH

ClearPath must be configured and tuned before it can be used in a motion application. The main configuration steps are outlined below. Each of these points is discussed in greater detail later.

1. Install ClearPath software (MSP) on a qualified Windows PC.
2. Connect your I/O devices to ClearPath (switches, PLC, microcontroller, etc.).
3. Supply DC power (24-75VDC) to ClearPath.
4. Connect ClearPath to your PC with a standard USB cable.
5. Use ClearPath MSP software to:
    a. Select a mode of operation.
    b. Set motion parameters and options (acceleration, velocity, torque, safety settings, etc.).
    c. Tune the motor/mechanical system.
6. Test and adjust settings as needed to optimize quality of motion and overall system performance.
7. Disconnect the computer and run your application. No computer is needed once setup is complete.

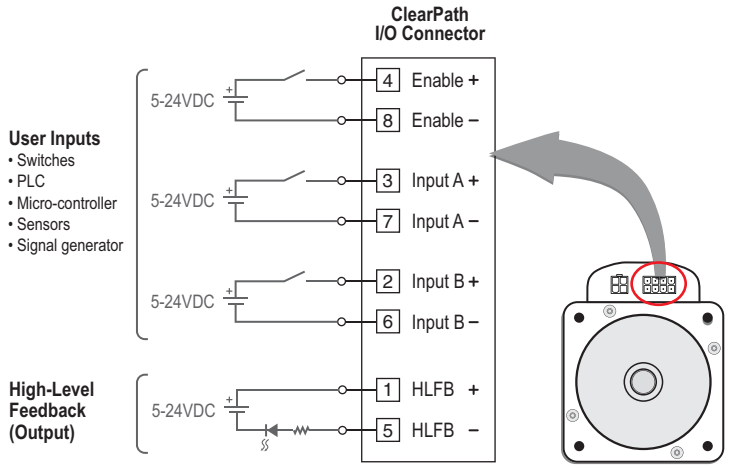
Save your settings! You can save your motor settings to a configuration file—the file extension is .mtr—at any time. This allows you to easily test and compare various sets of tuning parameters. And, if you build many machines of the same design you'll appreciate how quickly you can load a saved configuration file into a new ClearPath.

CLEARPATH I/O: OVERVIEW

ClearPath I/O provides a flexible high-level control interface for your ClearPath motor. There are no proprietary connectors, cables or sensors, so you decide which input devices are right for your ClearPath application.

Once the inputs are wired up, you'll be able to execute moves either by: 1) changing the logical (on/off) state of the inputs or 2) by applying a waveform to the appropriate input, depending on the mode of operation you choose. See "Interfacing To ClearPath I/O" for input and output wiring information.

Note: ClearPath inputs automatically change function based on mode of operation selected. See the Operation Mode section for input function.



Overview of ClearPath inputs and output

Enable Input. Asserting the Enable input (logical 1, high, 5–24VDC) energizes the motor coils. De-asserting Enable (logical 0, low state, 0 volts) removes power from the motor coils.

Inputs A and B. Once enabled, ClearPath can respond to the state of Inputs A and B. In the previous example, if Input A and B are both de-asserted (i.e. logical 0, low, zero volts) the load platform will move to position #1; if both inputs are switched high, the load platform will move to position #4.

ClearPath supports a wide range of input devices, from simple toggle switches to sensors, relays, PLC outputs, microcontroller outputs, and more can be wired to a ClearPath. And, when you change modes, the inputs automatically change function to match. ClearPaths motors have no tiny jumpers or DIP switches to manage.

High-Level Feedback (HLFB). ClearPath's HLFB output can be set up to alert the user or control system to one of several conditions. HLFB can be configured to:

- Change state if a Shutdown occurs.
- Assert when ClearPath is running at your commanded velocity or torque.

- Assert at the end of a settled move (based on user-defined settling requirements).
- Output a PWM signal proportional to motor speed.

GETTING STARTED

SELECTING A POWER SUPPLY

ClearPath motors can be powered from 24–75VDC (nominal), however the actual minimum DC voltage that will sufficiently power a given application is highly dependent on the application requirements (i.e. how much torque and speed are required) as well as motor winding and magnet configuration.

While Teknic power supplies have been extensively tested and widely used in ClearPath motor applications, third-party power supplies certainly can power ClearPath motors as well. See next page, or visit the Teknic website for power supply features, specifications, and pricing.

CLEARPATH POWER SUPPLY REQUIREMENTS

Nominal Operating Voltage = 24–75VDC*

Absolute Minimum Voltage = 21.5VDC*

Absolute Maximum Voltage = 90VDC*

* Voltages as measured at the ClearPath power connector.

The Ideal ClearPath Power Supply

...is capable of delivering high peak current and handling back-EMF (reverse voltage generated by the spinning motor that opposes, and effectively cancels a portion of the incoming supply voltage). “Bulk” linear supplies–basically a transformer, rectifier, and large capacitor–perform very well in servo applications.

Important: Thoroughly test your ClearPath application with the intended power supply *under worst case, full load conditions* to ensure sufficient power capacity and adequate power margin.

Why avoid switching power supplies?

Switching power supplies are typically not well suited to high power servo applications because they generally have the same peak *and* continuous-current ratings. This can lead the user to purchase a large but ultimately under-worked power supply just to meet peak current requirements.

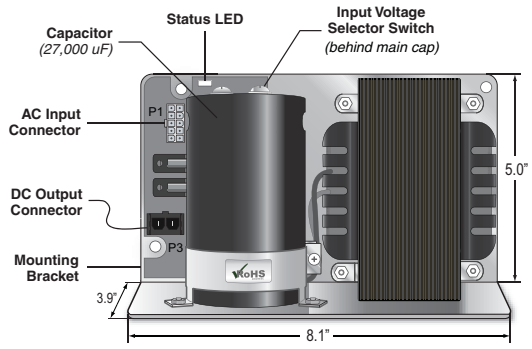
In addition, most switchers are not designed to handle the regenerated energy (back-EMF) that a decelerating motor returns to the power supply. Without special provisions, regenerated energy can cause a switching supply to reset, power cycle, shut down, or even fail.

TEKNIC POWER SUPPLIES

Teknic manufactures two field proven 75VDC nominal "bulk" linear power supplies appropriate for use with ClearPath motors. These supplies—specifically designed for use with servo systems—effectively manage peak current demand, regenerated energy, and include several built-in protective features.

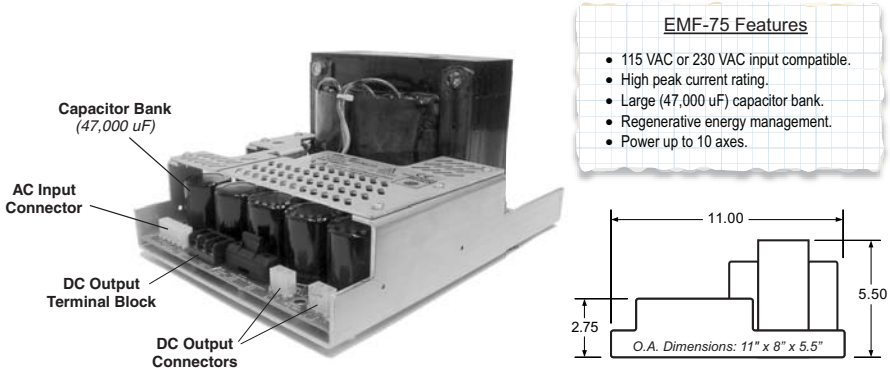
TEKNIC MODEL E3PS12-75

The E3PS12-75 power supply can power one ClearPath motor under worst case loading conditions, and as many as six ClearPaths in applications where current demand per motor is lighter and/or more evenly balanced. Visit Teknic's website for more information, features, and specifications.



Teknic E3PS12-75 Power Supply

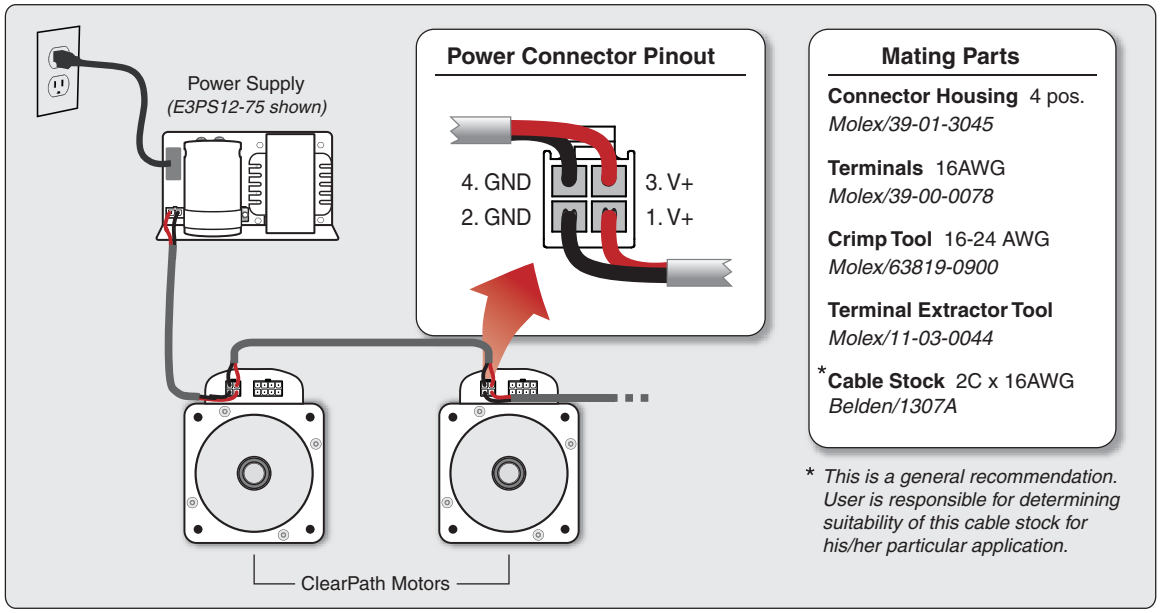
The EMF-75 power supply is Teknic's workhorse supply. It can power up to three ClearPath motors under worst case loading conditions, and as many as ten axes in lighter applications. Visit Teknic's website for full specifications and pricing information.



Teknic EMF-75 Power Supply

CONNECTING POWER TO A CLEARPATH MOTOR

Connect main DC power to the ClearPath power connector, a four position Molex Minifit Jr. connector. For applications with multiple ClearPath motors, power can be daisy-chained from motor to motor as shown below. The diagram below includes a list of power connector mating parts readily available from most electronic component suppliers.



ClearPath Power Supply Connection

BEFORE POWERING A CLEARPATH

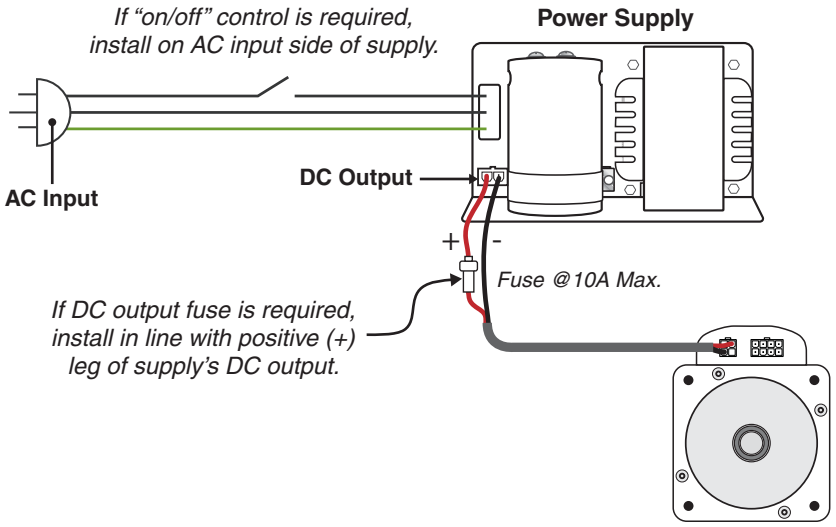
- Check for proper DC power polarity before connecting power to a ClearPath. Reversing DC power polarity may damage the unit and void the warranty.
- Make sure the power supply is turned off and discharged before connecting to a ClearPath. Connecting and disconnecting the motor from a charged power supply will cause electrical arcing that can damage the connector pins over time.
- Never connect a ClearPath motor directly to an AC outlet. This will damage the ClearPath motor and void the warranty.
- ClearPath NEMA 23 series motors auto- rotate upon power up to initialize (90° typ.) Call Teknic if power up motion is may be problematic.

POWER SUPPLY CONTROL SWITCH

The power supply for a ClearPath should not be switched on and off from the DC output side. Switching the DC output side, especially with inexpensive relays, will ultimately result in poor performance (drop outs) due to pitting, corrosion and contact welding. If a power switch is required, install it such that the supply is disconnected from the AC input side (see figure below).

POWER SUPPLY FUSING

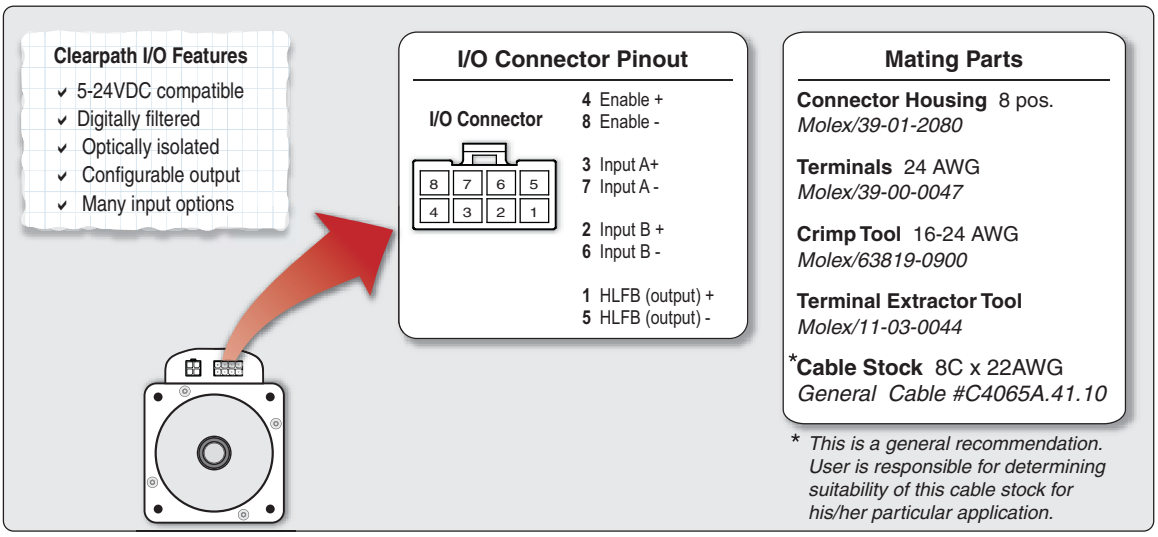
If an external fuse on the power supply's DC output is required to meet compliance standards, it should be installed in line with the positive leg of the DC output wiring (refer to diagram for fuse placement). Use a maximum 10A time delay fuse. Note: Teknic E3PS12-75 power supply *does not* have a fuse on the DC output side.



Power supply switching and fusing detail

CONNECTING I/O TO A CLEARPATH MOTOR

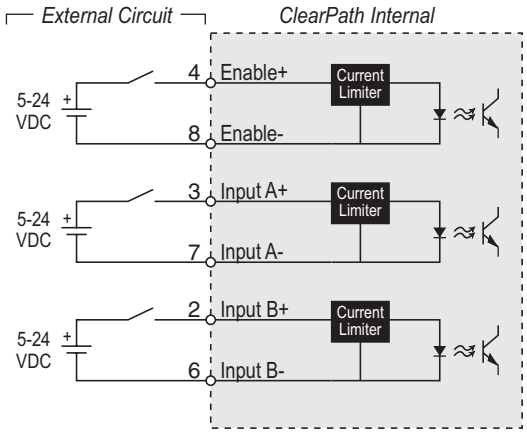
ClearPath I/O allows the user to send and receive control signals from a ClearPath motor. There are a total of three digital inputs and one digital output accessible through the 8-position Molex MiniFit Jr. connector. Refer to the diagram below for a list of I/O connector mating parts readily available from most electronic component suppliers.



ClearPath I/O connector and mating parts

CLEARPATH INPUTS

The three inputs, designated *Enable*, *Input A*, and *Input B*, are designed for use with 5-24 VDC logic levels and pulses from a wide variety of signal sources and devices including PLCs, microcontrollers, and even simple switch and battery rigs (with no external resistors required). They are optically isolated, digitally filtered, current limited, and reverse polarity protected for robust, long-term performance.



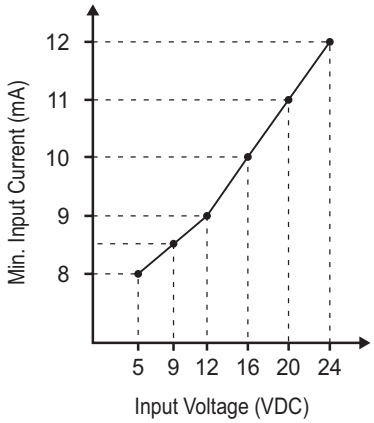
ClearPath Inputs shown with simple switch and battery inputs

Tip: To make a simple manual controller—for modes that don't require pulses—wire a few toggle switches and a 9V battery to the ClearPath inputs (see diagram on previous page.) The inputs are internally current limited, so there's no need for external current limiting resistors.

MINIMUM INPUT CURRENT REQUIREMENT

Devices wired to ClearPath inputs must be able to source/sink a minimum current value as described in the figure below.

Tip: if your device (PLC, microcontroller, power supply) can source or sink at least 12mA, you're covered for all typical input voltages.

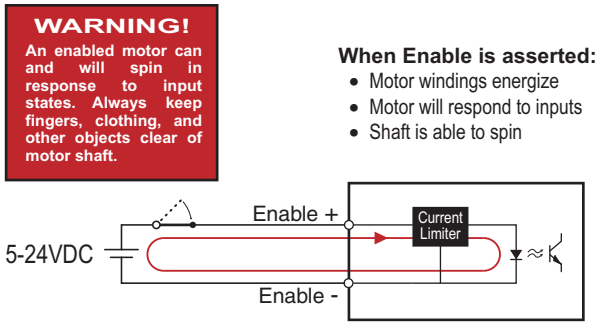


Voltage at ClearPath Input	Minimum Input Current Required
5 VDC	8 mA
12 VDC	9 mA
24 VDC	12 mA

Minimum Input Current

ENABLE INPUT

The Enable Input controls power to the motor coils. When a ClearPath is powered up and the Enable Input is asserted (i.e. 5–24VDC is present at the input) the motor windings energize and ClearPath is able to respond to control signals at Inputs A and B. When Enable is de-asserted (0 volts applied) power to the motor coils is shut off and the motor cannot respond to user inputs[1].



ClearPath Enable Input

Caution: When ClearPath is in "Spin on Power-Up" mode, it can spin as soon as main DC power is applied. All inputs, *including the Enable Input*, are ignored in this mode.

[1] **Exception:** when ClearPath is set to "Spin on Power Up" mode, the motor shaft can move as soon as main DC power is applied, regardless of the state of the Enable Input.

Enable-With-Trigger function. In some ClearPath modes, the Enable input also serves as a trigger input. In these modes, briefly pulsing the Enable input low (and immediately back high again) causes ClearPath to perform a predefined action, such as execute a move, change direction of rotation, or change velocity. See individual operation modes for trigger mode details.

INPUTS A AND B: THE CONTROL INPUTS

Inputs A and B are the main user control inputs. Their function changes automatically based on the ClearPath mode of operation you choose. In some modes simply apply a PWM signal to control velocity or torque. In other modes, set the inputs high or low to move a preset distance, ramp to a target velocity, change direction, or move until a sensor trips. For ClearPath SD models, apply standard step and direction signals to the inputs to create your own motion profiles.

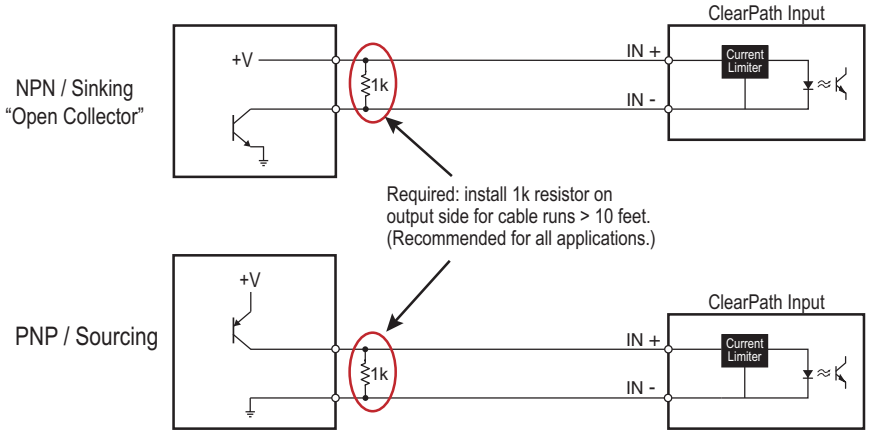
Tip: All Input functions for a given mode are defined in a table located at the beginning of each operational mode section.

Engineer's Note: In all ClearPath motors, the logic-level signals are electrically isolated from the DC power input and motor output circuits, as well as from the motor case. This design feature ensures that control signals will not be compromised due to induced currents from the motor, power supply, or PWM return path.

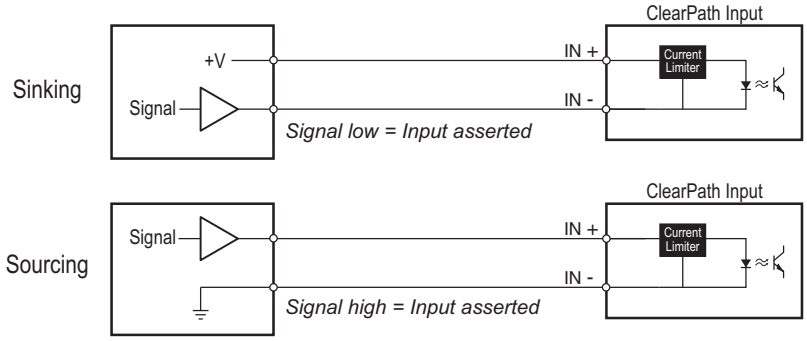
CONNECTING DIGITAL OUTPUTS TO CLEARPATH INPUTS

ClearPath inputs are compatible with standard digital output formats including open collector transistor, and driven outputs from PLCs, sensors, signal generators, microcontrollers and more.

Transistor Outputs



Driven Outputs, Single-Ended



Interfacing digital outputs to ClearPath Inputs

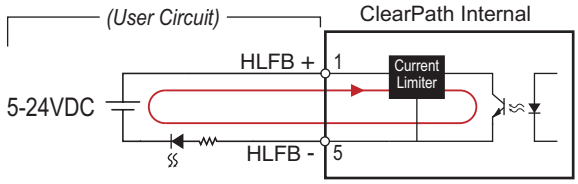
CLEARPATH OUTPUT (HIGH-LEVEL FEEDBACK)

High-Level Feedback (HLFB) is ClearPath's sole digital output. HLFB can be wired to external devices, such as the input of a PLC, microcontroller, or even a simple LED to signal the presence of specific motion conditions.

HLFB settings can be found on the Advanced drop down menu in ClearPath MSP. This output can be left as a "no connect" if desired.

Note: HLFB is not internally powered and so requires an external 5–24VDC power source capable of sourcing/sinking at least 15mA. In typical applications power is supplied by the user's PLC, control board, or external supply.

Note: Not all HLFB modes are supported in all ClearPath operational modes. Refer to individual ClearPath operational mode for supported HLFB options.



High-Level Feedback circuit (shown driving an LED)

HIGH-LEVEL FEEDBACK MODES

Servo On

In Servo On mode, the HLFB output asserts (goes high) when ClearPath is enabled and not in a shutdown state. This signal can be used to monitor ClearPath for shutdowns, or as the control signal for an external brake.

Speed Output

In Speed Output mode, ClearPath produces a 50 Hz PWM waveform whose duty cycle is proportional to motor speed. This signal can be used as the input to a simple speedometer or tachometer. Note: The user must use external circuitry or an appropriate device to interpret PWM signals.

All Systems Go-Position

This mode is typically used as a "move done" signal. In ASG-Position mode, the HLFB output asserts (goes high) when ClearPath is enabled *and* settled within a user-specified distance from the target position for a user-specified period of time. For example, the output can be set to assert when the motor is within 10 counts of the target position for at least 10 mS.

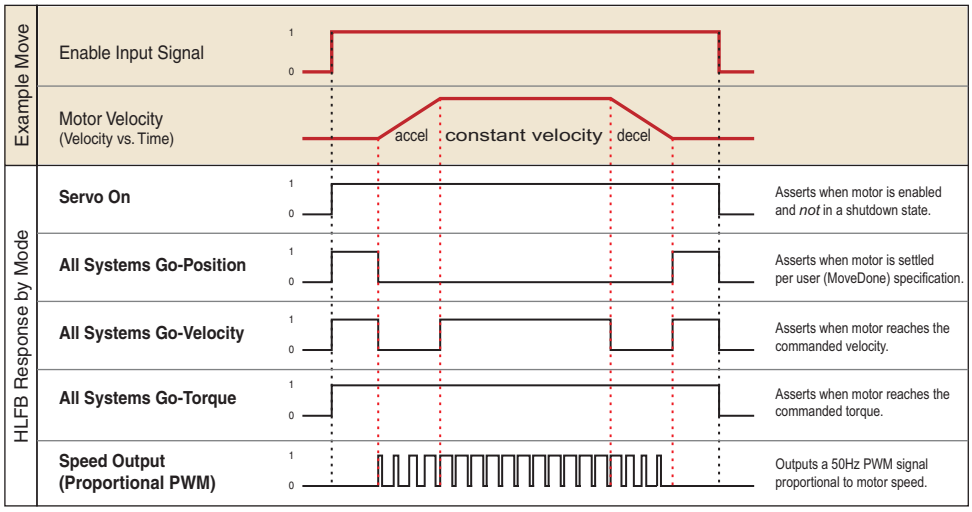
All Systems Go-Velocity

This mode is most often used to signal when ClearPath has reached commanded velocity. In ASG-Velocity mode, the output asserts (goes high) when ClearPath is enabled and running within a certain tolerance

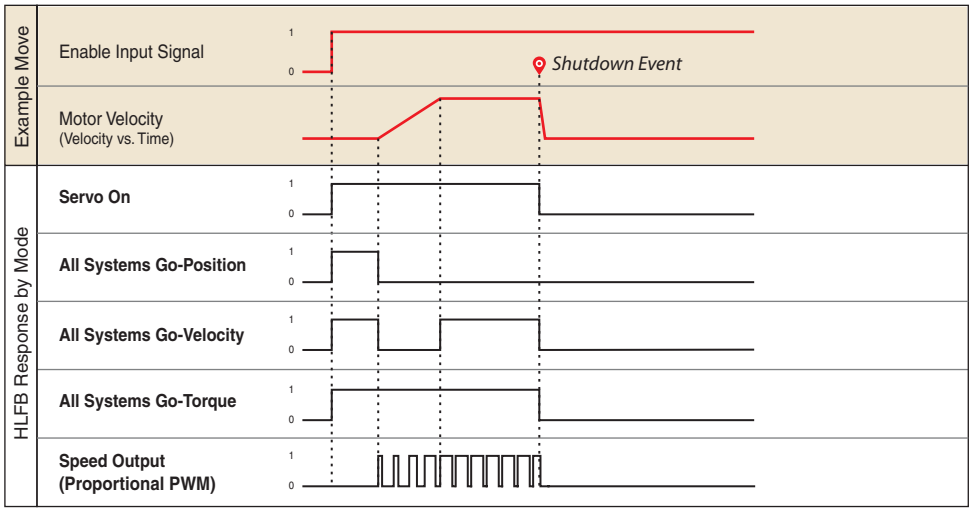
band of the commanded velocity[2]. This output can be used to signal when a conveyor or rotary tool has reached operating speed. Note: this signal is de-asserted (low) during periods of acceleration and deceleration.

All Systems Go-Torque

In ASG-Torque mode, the HLFB output asserts (goes high) when the ClearPath is enabled and the motor shaft is within a tolerance band of the user-specified torque.



High-Level Feedback timing during a typical move cycle



High-Level Feedback timing before and after a shutdown

[2] In All Systems Go-Velocity mode, the output asserts when actual motor velocity is within +/- 3% of the commanded velocity or within 24RPM of the commanded velocity, whichever value is greater.

USER SOFTWARE (CLEARPATH MSP)

SECTION OVERVIEW

This section includes the following topics:

- ClearPath MSP System requirements
- Installing ClearPath MSP software
- Communicating with ClearPath
- Tour of ClearPath MSP
- Overview: Advanced Features

MINIMUM SYSTEM REQUIREMENTS

Operating System:	Win XP SP3 or later, Win 7
Processor:	1 GHz or faster
Memory:	512 MB
HD Free Space:	512 MB
Monitor:	1280 x 1024 pixels or higher
Other:	Sound card with speakers (optional)

INSTALLING MSP

Launch the MSP installer and follow the on-screen prompts. Please contact Teknic if you have problems with software installation.

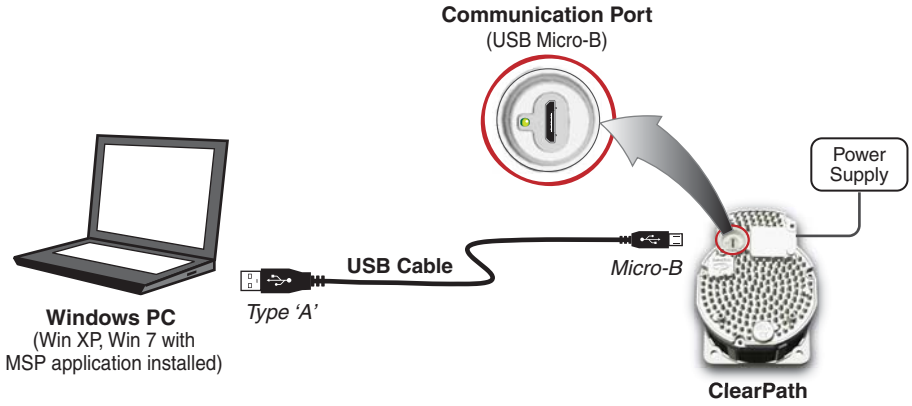
COMMUNICATING WITH CLEARPATH

After ClearPath MSP is installed on your PC, follow the directions below to establish a communication link between your ClearPath and PC.

Note: Establishing a ClearPath communication link is required for setting operational modes, defining move parameters and options, tuning the motion system, and using the MSP Scope to analyze system performance.

ITEMS REQUIRED FOR COMMUNICATION SETUP

- A ClearPath Motor
- A DC power supply (24–75VDC nominal) and cable
- A PC running Windows XP or Windows 7 with ClearPath MSP installed
- A USB cable (Type A to Micro-B)



ClearPath Communication Setup

FIRST-TIME COMMUNICATION SETUP

1. **Install MSP** software on a qualified Windows PC. See previous page for Minimum System Requirements.
2. **Power up ClearPath.** Apply 24-75VDC to the power input connector. Note: A lab power supply can be used for basic communication and low power, low speed testing.
3. **Connect ClearPath to the PC** with a USB Type "A" to Micro-B cable. This is a low cost standard cable.
4. **Wait!** In most cases Windows will detect the connected ClearPath and install the correct USB driver automatically. This step can take a few minutes to complete. Proceed only after Windows reports the device is installed and ready for use.
5. **Launch MSP** software by double clicking the desktop icon or selecting from the Programs menu: Teknic>ClearPath MSP> ClearPath MSP Setup Program.

Additional Notes

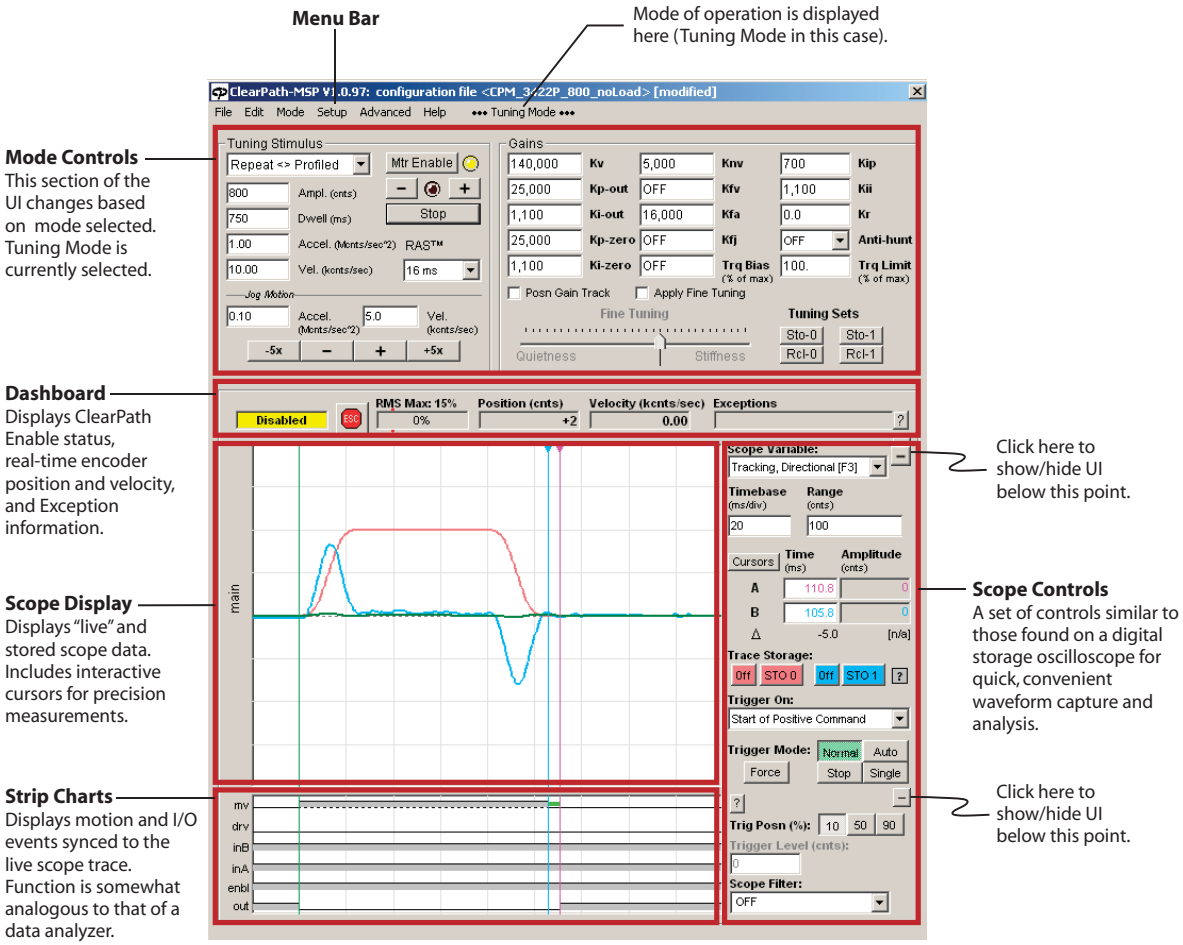
MSP is designed to communicate with one ClearPath at a time. There is no networking provision.

Before tuning a ClearPath, the motor must be powered up, connected to a PC running MSP, and enabled.

The host PC can be disconnected after configuration and tuning are complete. While ClearPath does not use a PC connection during normal operation, you *can* connect a PC to ClearPath at any time for manual control, system analysis, diagnostic and troubleshooting tasks.

TOUR OF CLEARPATH MSP

UI OVERVIEW



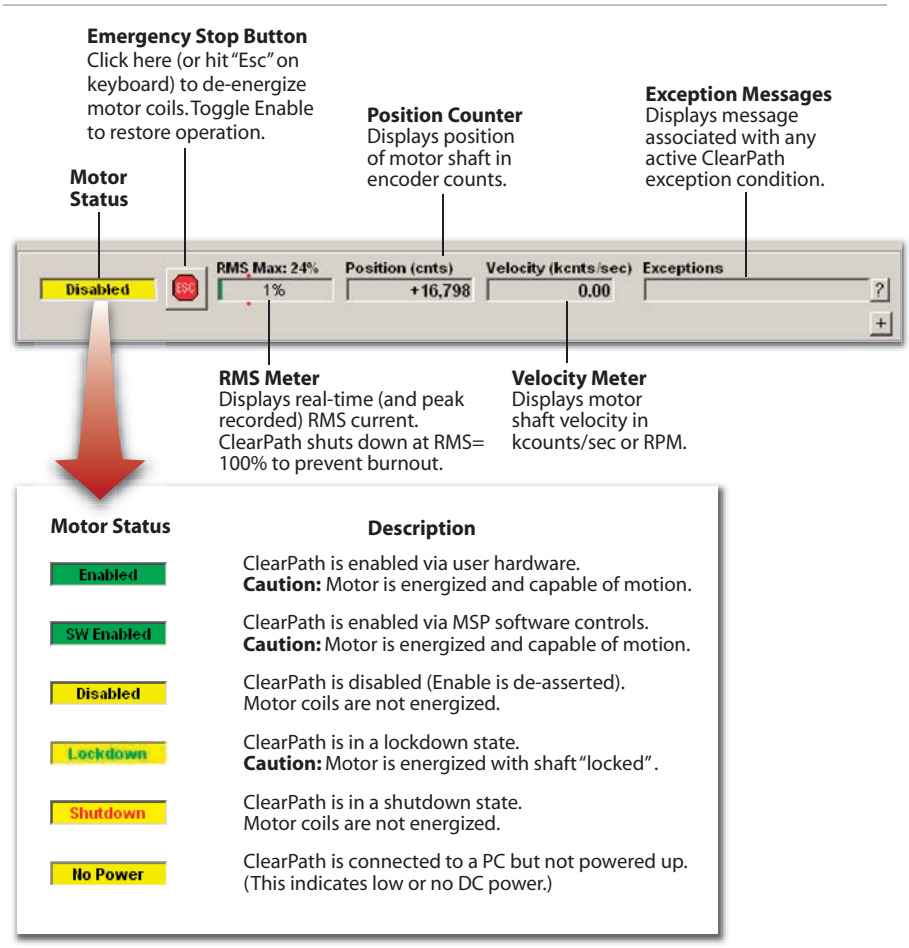
ClearPath MSP User Interface

MODE CONTROLS

The Mode Controls section is the user input area of MSP. This part of the UI changes based on the mode of operation selected. The Mode Controls are used to:

- **Enter motion parameters and settings** related to the currently selected mode, including position, acceleration, velocity, torque, and homing parameters.
- **Access Soft Controls.** Soft Controls allow you to spin your ClearPath with no hardware inputs connected. With just MSP and a powered up ClearPath, you can enable the motor, turn the inputs on and off, command motion, and monitor the output state. Soft Controls are invaluable for configuration, testing, and troubleshooting tasks.

DASHBOARD



MSP Dashboard

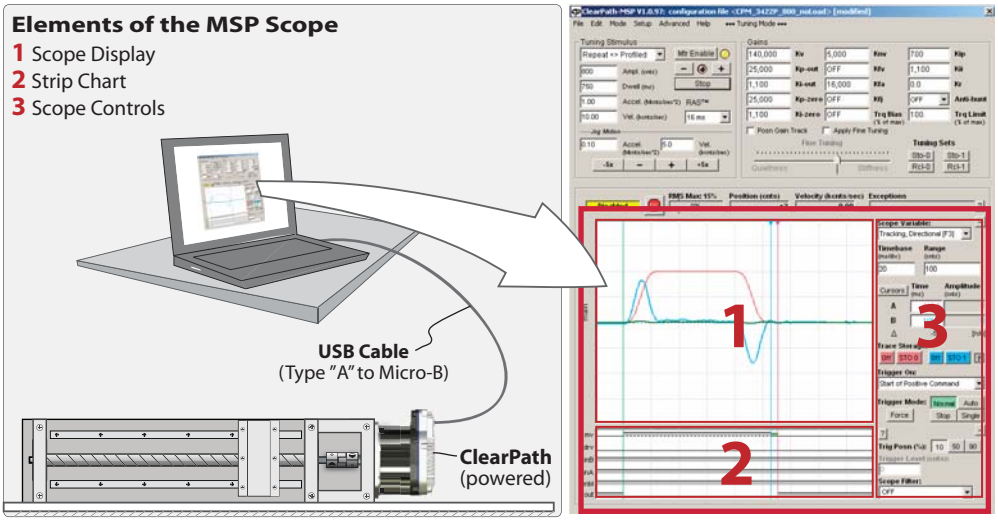
Note: The Position Counter is not displayed in velocity or torque modes.

MSP SCOPE

OVERVIEW

The MSP Scope takes real-time streaming data from ClearPath and plots it on the Scope Display to provide a dynamic picture of motor performance. The scope can be used to display your motor's current torque output, tracking error, commanded velocity, acceleration, and more. Feedback from the scope is critical for motor tuning, servo gain refinement, and in the analysis and troubleshooting of electrical, mechanical, and motion-related problems.

The MSP Scope consists of three major sections: the Scope Display (1), Strip Chart (2), and Scope Controls (3). These components, taken together, emulate much of the functionality of a digital storage oscilloscope and data analyzer.



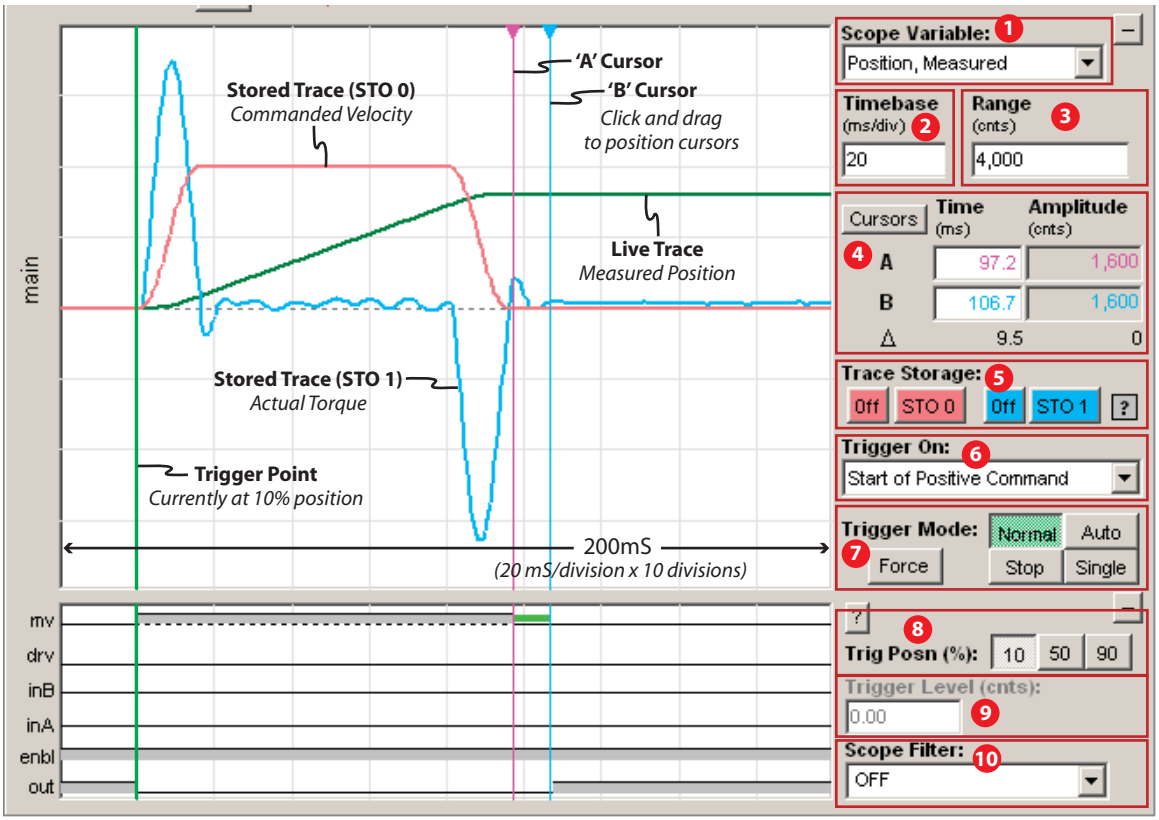
MSP Scope Overview

SCOPE FEATURES

- Twelve scope variables.
- Four trigger modes.
- Adjustable time base, range, and trigger position.
- Two stored traces + one live trace.
- Twelve trigger source presets.
- Interactive cursors for precise time and amplitude measurements.
- Strip Chart to display synchronous move, drive, and I/O event timing.

SCOPE DISPLAY AND SCOPE CONTROLS

The MSP Scope display is modeled after that of a typical hardware oscilloscope; as such, it has 10 major vertical divisions on the time axis and 8 major horizontal divisions on the amplitude axis.



MSP Scope

1 The Scope Variable drop down menu lets you select any of 12 ClearPath motion control variables to display. These variables include Tracking Error, Commanded Velocity, Actual Torque, Actual Velocity, Velocity Error, Commanded Torque, SGN (sign of velocity), Measured Position, Commanded Jerk, Commanded Acceleration, Max Phase Voltage, and Torque Error.

2 The Timebase text box lets you adjust the scale of the time axis (think Cartesian X-axis) in units of mS/division. This allows you to control how a waveform fits horizontally on the Scope Display. For example, if the Timebase is set to 20mS per division (as in the figure above) the full horizontal range of the scope is 200mS (10 divisions x 20mS/division).

3 The Range text box lets you change the scale of the amplitude axis (think Cartesian Y-axis). This allows you to control how a waveform fits vertically on the Scope Display. For example, in the figure above the green trace represents Measured Position and the Range is set to 4000 counts. So in this case, the center horizontal line represents 0 counts, the top horizontal line represents (+)4000 counts, and the bottom line represents (-)4000 counts.

4 Cursor controls allow you to drag the two vertical cursors around on the main scope display and view time and amplitude measurements in

real time. The delta function automatically displays the difference between cursor values.

5 Trace Storage controls allow you to save and overlay up to two traces on the scope display. Just capture a waveform and click either the STO0 or STO1 button (Storage 0 and Storage 1). The selected trace is then stored and displayed in either pink (STO0) or blue (STO 1). Hide or show either stored trace by clicking its associated On/Off button.

6 The Trigger Source ("Trigger On") drop down menu lets you choose what condition(s) must be met before scope data collection is triggered. The following Trigger Source options are available:

If Trigger Source is set to:	MSP Scope will:
Start of Positive Command	Trigger at the start of any positive move; useful for tuning.
Start of Negative Command	Trigger at the start of any negative move; useful for tuning.
Start of Any Command	Trigger at the start of any move (positive or negative); useful for assessing bi-directional tuning performance.
End of Positive Command	Trigger at the end of any positive move; useful for assessing settling performance.
End of Negative Command	Trigger at the end of any negative move; useful for assessing settling performance.
End of Any Command	Trigger at the end of any move (positive or negative); useful for assessing bi-directional settling.
End of Positive Settled Move	Trigger at the end of any positive move after Move Done criteria are met; useful for assessing settling performance.
End of Negative Settled Move	Trigger at the end of any negative move after Move Done criteria are met; useful for assessing settling performance.
End of Any Settled Move	Trigger at the end of any move (positive or negative) after Move Done criteria are met; useful for assessing settling performance.
Voltage/Torque/Speed Limit	Trigger on first occurance of saturation (voltage *or* torque) or upon speed limiting; useful for determining which moves (or segments of moves) exceed these thresholds.
Drive Shutdown or Exception	Trigger on the assertion of an exception or safety shutdown; useful for determining the operational status at the time of a fault.
Rising Slope	Trigger on the rising edge of the active waveform.
Falling Slope	Trigger on the falling edge of the active waveform.

7 Trigger Mode settings allow you to select exactly when data acquisition begins and ends. These controls are analogous to the trigger modes found on a digital storage oscilloscope.

- **Normal** - Causes scope data collection to occur whenever a valid trigger source is detected.
- **Single** - Works the same as *Normal* mode, except it captures only a single data set when a valid trigger source is detected.

After the single sweep capture, data collection automatically stops.

- **Auto** - This is the rolling, "always on" setting. Data is continuously collected, refreshed, and displayed regardless of the trigger source settings.
- **Force** - Forces the scope to trigger immediately, regardless of trigger source setting. As with Single mode, only one data set is collected and displayed; then data collection stops.
- **Stop** – Causes scope data collection to stop. It does *not* clear previously captured data from the scope display.

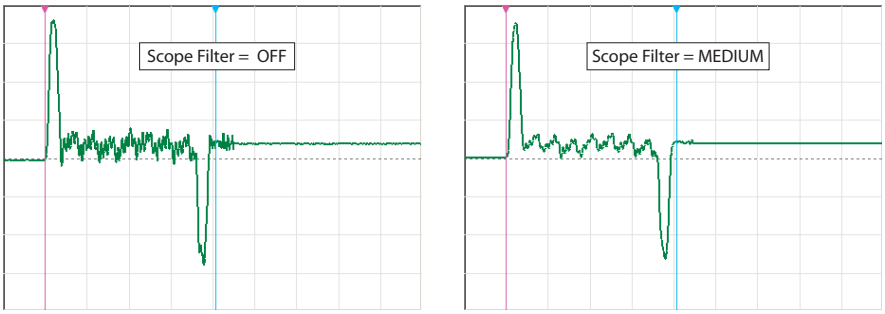
8 **Trigger Position** buttons allow you to position the trigger point on the left (10%, as shown in the previous figure), middle (50%), or on the right side (90%) of the scope display grid. This is useful for viewing events on the scope that occur before, during, or after the trigger point.

9 **The Trigger Level** lets you select the amplitude at which the scope will trigger.

Note: Trigger Level can only be used when Trigger Source is set to "Rising Slope" or "Falling Slope".

Tip: Use Trigger Level when the Trigger Mode is set to "Normal" or "Single" to facilitate waveform display at a fixed trigger point.

10 **The Scope Filter** effectively "cleans up" the appearance of the displayed trace by removing higher frequency data content. This has an averaging effect on the displayed data that can help mitigate the effect of noise (or just unnecessary visual clutter) on the displayed signal.



Effect of Scope Filter on trace display

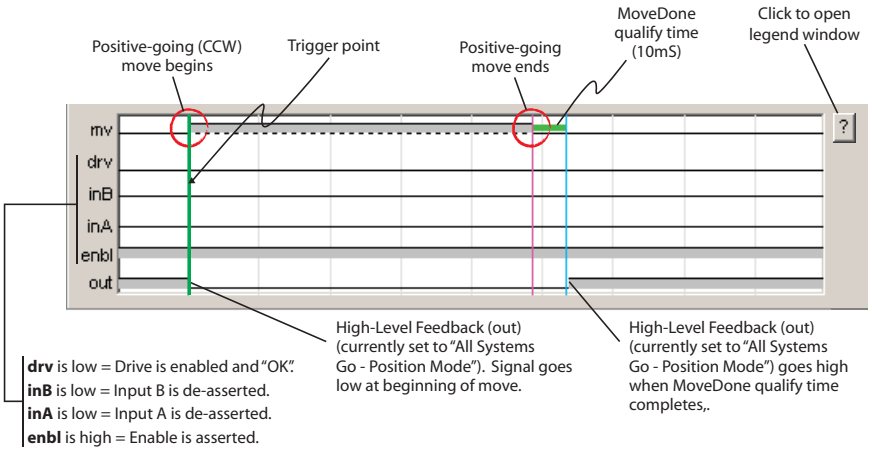
Note: The Scope Filter has no effect on motor performance. *It changes only how scope data is displayed.*

Note: Higher filter setting may filter out meaningful data points from the display (peaks in particular).

Tip: In most cases Scope Filter can be left "OFF" or at the lowest setting.

STRIP CHART

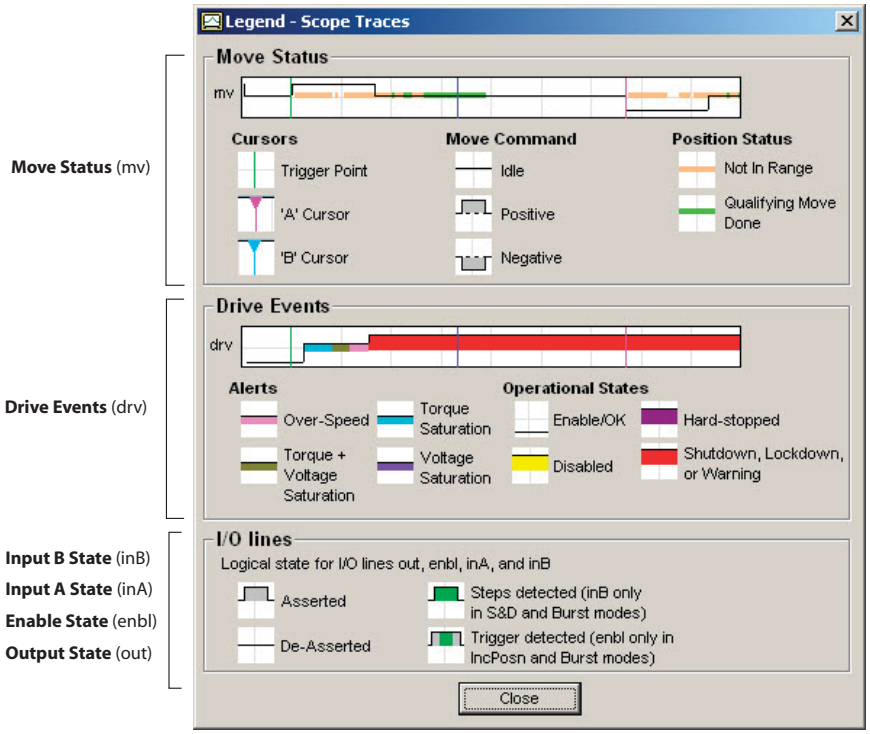
The Strip Chart can display a number of additional events and conditions that occur in sync with the primary waveform capture. Using the Strip Chart you can view move status (mv), drive events (drv), and I/O states in real time. And, because the Strip Chart display is always auto-synchronized to the main scope trace, there are no settings to deal with.



MSP Strip Chart display

Strip Chart Legend

MSP includes a helpful reference chart to help you interpret what's happening on the strip chart. To open the legend window click the ? symbol to the right of the strip chart display.



MSP Strip Chart Legend

CLEARPATH MENU

FILE MENU

Load Configuration (Ctrl+0). Use this command to load saved ClearPath configuration files (extension .mtr) to your ClearPath.

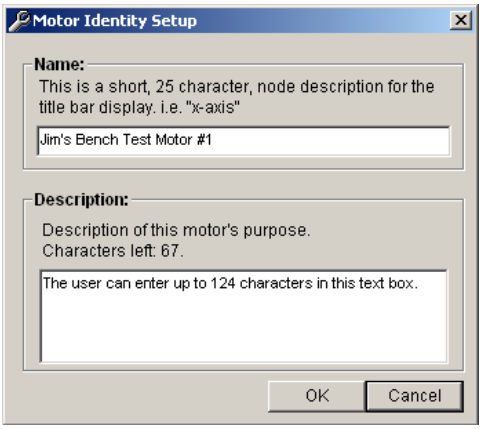
Save Configuration (Ctrl+s). Use this command to save your ClearPath configuration settings to a .mtr file.

Reset Config File to Factory Defaults. This command restores ClearPath to its factory default configuration.

EDIT MENU

Cut (Ctrl-x), Copy (Ctrl-c), and Paste (Ctrl-v) are the standard Windows Edit commands.

Motor ID. Opens a window that lets you enter a name and brief description for your ClearPath if desired.



Zero Position (Ctrl+0) Sets the Position Counter to zero. Note: In certain modes, double-clicking the Position Counter directly in the UI will also zero the counter.

Reset RMS Peak Note: This applies to the RMS Meter in the Dashboard section of MSP. Click this menu item to reset *RMS Max* (this is the maximum RMS value recorded since last reset).

MODE MENU

Select ClearPath operating modes from this drop down menu. Note: number of available modes varies by model.

SETUP MENU

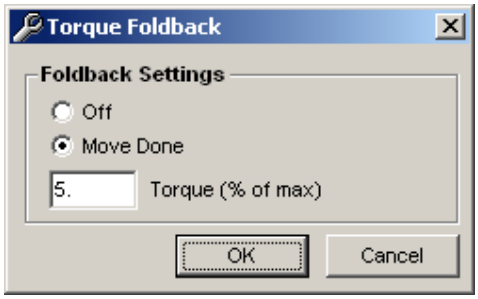
Use this menu item to convert velocity and acceleration values from encoder counts to RPM (revolutions per minute). Note: Motor position is *always* displayed in encoder counts.

ADVANCED MENU

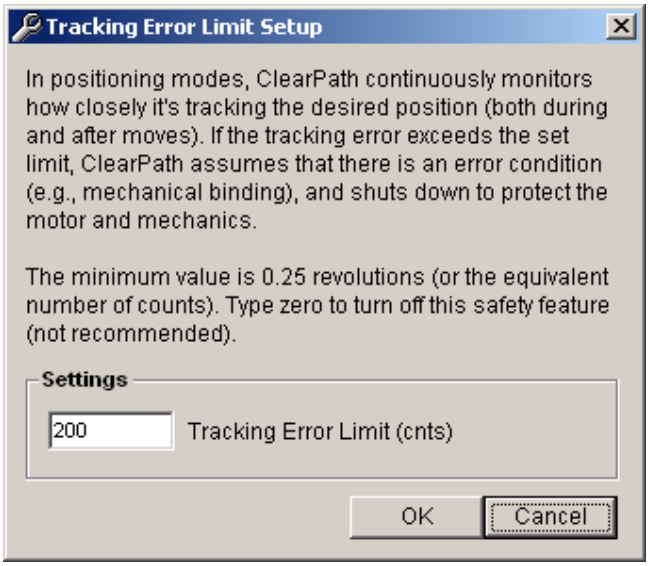
The Advanced menu gives you access to several ClearPath global features and settings. Each Advanced Menu item is listed below along with a screenshot of its dialog window.

Torque Foldback

This feature automatically limits maximum available torque to the user-specified value whenever the Move Done criteria are met. See Move Done criteria (next page) for details.



Tracking Error Limit

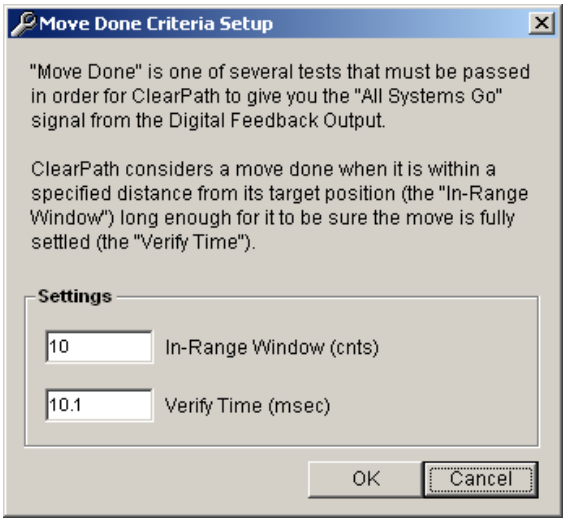


High-Level Feedback

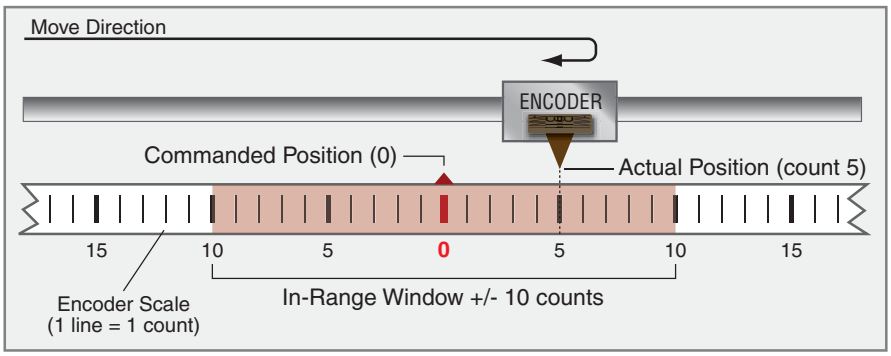
Please see section on High-Level Feedback.

Move Done Criteria

Move Done status is used to determine when the All Systems Go-Position signal should be asserted at the HLFB output. The Move Done Criteria consist of two parameters: the “In-Range Window” and the “Verify Time”. These parameters are explained in the screen capture, taken from MSP, below.



Move Done setup dialog



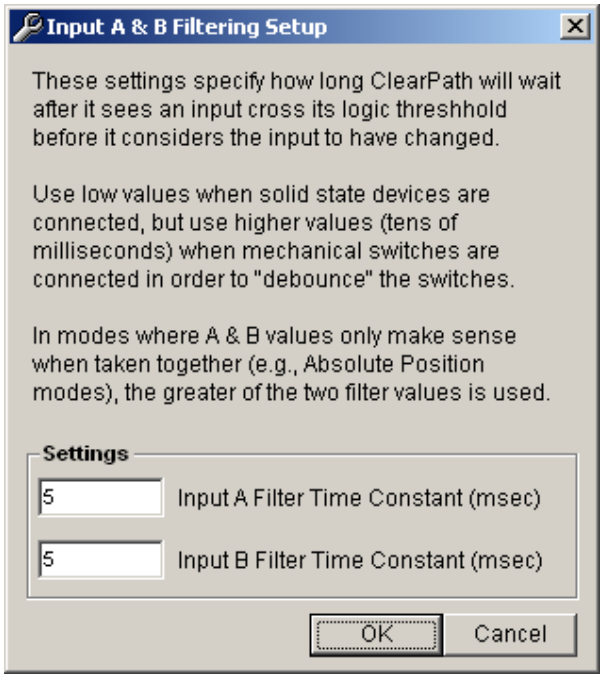
How Move Done Works

Move Done status is achieved when both of the Move Done criteria are met. In the above figure, Move Done occurs only when the motor is within +/-10 encoder counts of the commanded position (the In-Range Window) for a minimum of 10.1 milliseconds (the Verify Time).

Note: If the encoder swings out of the In-Range window during the Verify Time, the Move Done timer automatically resets. The timer starts a new countdown only when the motor is back within the In-Range window.

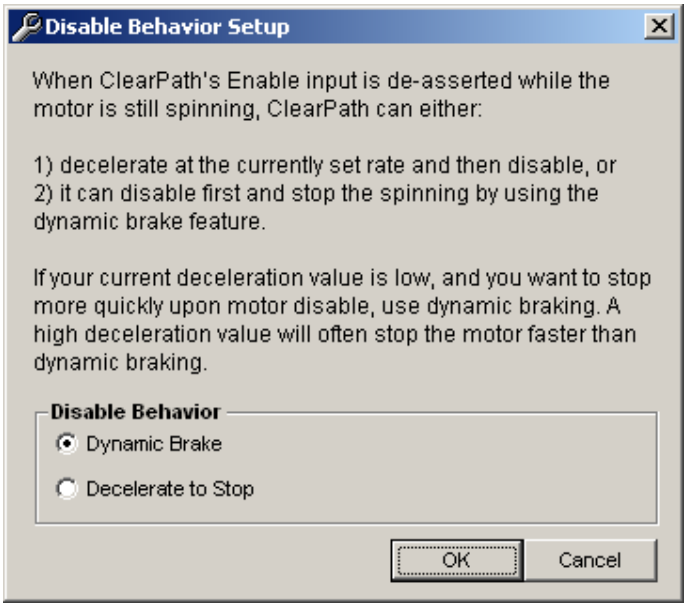
Because mechanical systems and settling performance requirements vary by application, the user may need to experiment a bit to determine appropriate values for the In-Range Window and Verify Time.

Input A and B Filtering



Disable Behavior

This setting determines how ClearPath will decelerate if it is disabled while still in motion.



MODES OF OPERATION: MC FAMILY

This section discusses ClearPath MC Family modes of operation, including input/output functions, timing and software features and functions.

TABLE OF CLEARPATH MC FAMILY OPERATIONAL MODES

Operation Mode	Model		Description
	MCVC	MCPV	
VELOCITY CONTROL MODES			
Spin On Power Up	✓	✓	Just turn on power and smoothly ramp to your preset velocity. For when all you need is reliable, constant velocity from a brushless motor, and a bare minimum of wiring. It doesn't get any easier than this.
Manual Velocity Control	✓	✓	Fine control of velocity from zero to max velocity at the turn of a knob. Remembers your last set velocity or resets to zero velocity when motor is enabled.
Ramp Up/Down to Selected Velocity	✓	✓	By changing digital inputs (from your PLC, switches, etc.), ClearPath will smoothly ramp to one of four preset velocities.
Follow Digital Velocity Command Bipolar PWM Command	✓	✓	Connect a digital waveform (PWM or frequency) from your PLC or other device, and ClearPath will run at a velocity proportional to the waveform. Or, use the PWM output from an H-bridge driver of a brushed motor setup and ClearPath becomes a high-performance drop-in replacement.
Follow Digital Velocity Command Unipolar PWM Command	✓	✓	
Follow Digital Velocity Command Frequency Command	✓	✓	
TORQUE CONTROL MODES			
Follow Digital Torque Command Bipolar PWM Command	✓	✓	ClearPath will apply a variable torque (or force or tension) in proportion to a digital command (PWM or frequency) supplied to the inputs.
Follow Digital Torque Command Unipolar PWM Command	✓	✓	
Follow Digital Torque Command Frequency Command	✓	✓	
POSITION CONTROL MODES			
Move to Sensor Position	✓	✓	Use ClearPath digital inputs to spin the shaft CW or CCW. Wire your position sensors or switches in series with the inputs to make an inexpensive two position actuator.
Move to Absolute Position (2 Positions)	✓	✓	Command ClearPath to move to one of two preset locations. Perfect for replacing air cylinders that move between two positions.
Move to Absolute Position (4 Positions)	✗	✓	Command ClearPath to move to one of four preset locations. Perfect for replacing air cylinders where more power and finesse is needed, and you want to position at more than just two positions.
Move Incremental Distance (2 Distances)	✗	✓	Trigger ClearPath to move a user-defined distance (one of two) from its current position. You can also send multiple, quick trigger pulses to tell ClearPath to travel a multiple of any of its user-defined distances in one smooth move.
Move Incremental Distance (4 Distances)	✗	✓	Trigger ClearPath to move a user-defined distance (one of four) from its current position. You can also send multiple, quick trigger pulses to tell ClearPath to travel a multiple of any of its user-defined distances in one smooth move.
PULSE POSITIONING MODE			
Pulse Burst Positioning	✗	✓	Use a timer/counter on your PLC (or a simple circuit) to send a burst of pulses to ClearPath, and it will move a distance proportional to the number of pulses sent, at your preselected velocity and acceleration. This mode gives you most of the flexibility of a "step & direction" motion controller without the cost and added complexity.

SPIN ON POWER UP

MODE SUMMARY

This is ClearPath's simplest mode of operation. Just turn on power and ClearPath smoothly ramps to your preset velocity. Use this mode for applications that require reliable constant velocity and a bare minimum of wiring.

HOW IT WORKS

Apply main DC power and ClearPath immediately ramps up to your target velocity (target velocity and acceleration are defined by the user during setup). ClearPath spins at the target velocity until DC power is removed. All inputs are ignored, but the output (High-Level Feedback) is functional.

Note: When power is removed in this mode, ClearPath may stop abruptly or coast a short distance depending on the application and motor winding configuration. Carefully test your loaded ClearPath application for stopping behavior before deploying.

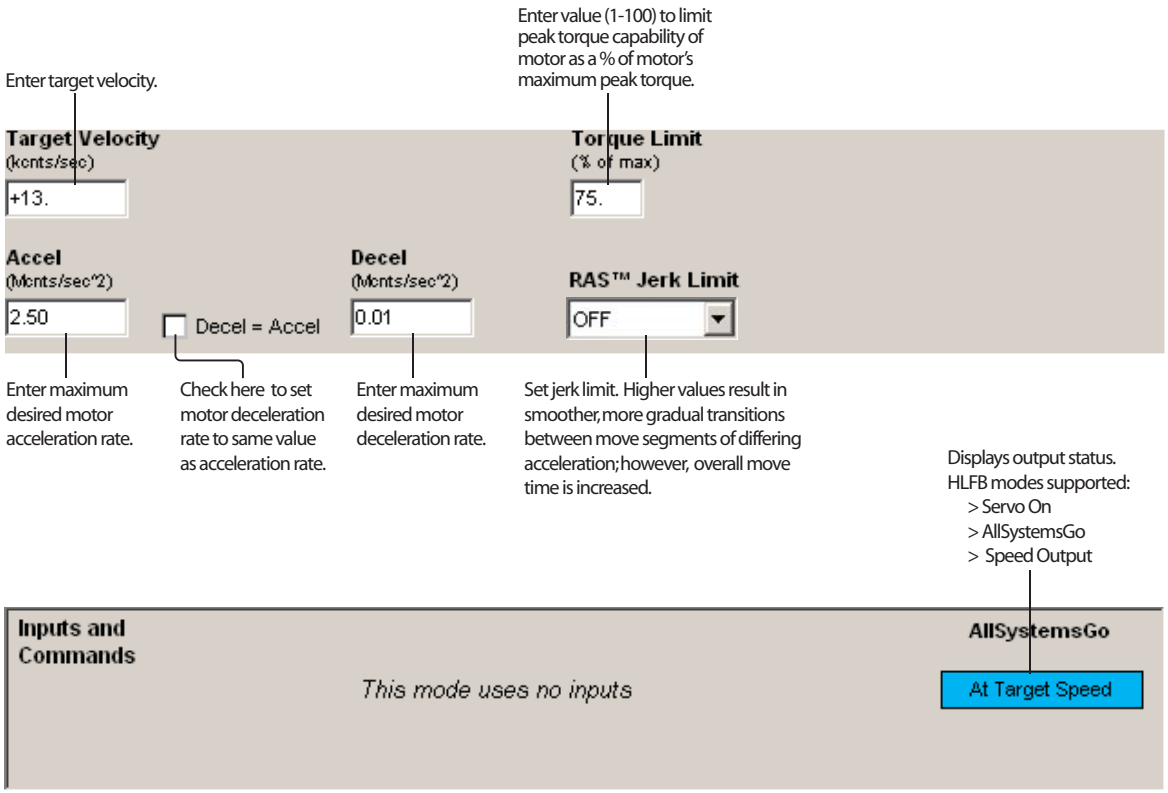
Velocity Control Spin On Power Up

Signal	Function	Input Type	Example Timing
Input A	Disabled	NA	1 0 NA
Input B	Disabled	NA	1 0 NA
Enable	Disabled	NA	1 0 NA
Main DC Power			ON OFF
Caution! Motor shaft may spin as soon as main DC power is applied. **Notes:** All inputs are ignored in this mode. High-Level Feedback is available. Motor will free-wheel when DC power is removed, unless external braking force is applied. Motor may stop abruptly depending on load conditions.			v t Motor velocity vs. time

Motor free-wheeling

Spin-On-Power-Up Mode: Inputs and Timing Diagram

MODE CONTROLS



MANUAL VELOCITY CONTROL

MODE SUMMARY

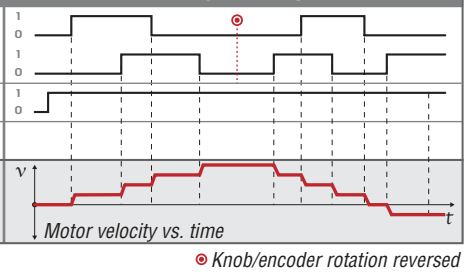
This mode offers fine velocity control from zero to max at the turn of a quadrature output encoder. Turn in one direction to increase clockwise motor velocity; turn in the other direction to increase counterclockwise velocity. ClearPath can be set to resume last velocity or start at zero velocity each time it's enabled.

HOW IT WORKS

Assert the Enable Input to energize the motor. Then, control motor velocity by sending quadrature signals to ClearPath Inputs A and B. Each quadrature signal transition (or "tick") received by ClearPath causes an incremental increase or decrease in motor velocity, depending on which direction the encoder is turned (i.e. whether phase A leads B or B leads A).

Velocity Control **Manual Velocity Control**

Signal	Function	Input Type	Example Timing
Input A	Velocity Control A	Quadrature	
Input B	Velocity Control B	Quadrature	
Enable	Enable	Logic: High=Enable Low=Disable	
Trigger	NA	NA	
Notes:			



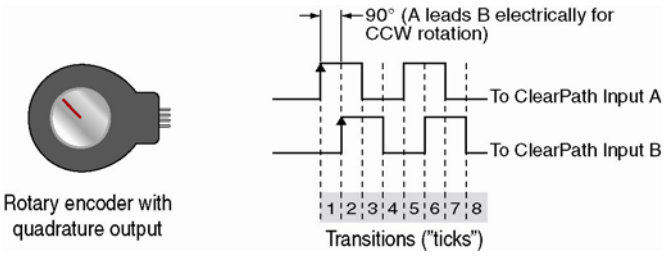
Manual Velocity Control: Inputs and Timing Diagram

Notes:

- Disable time = 10 mS

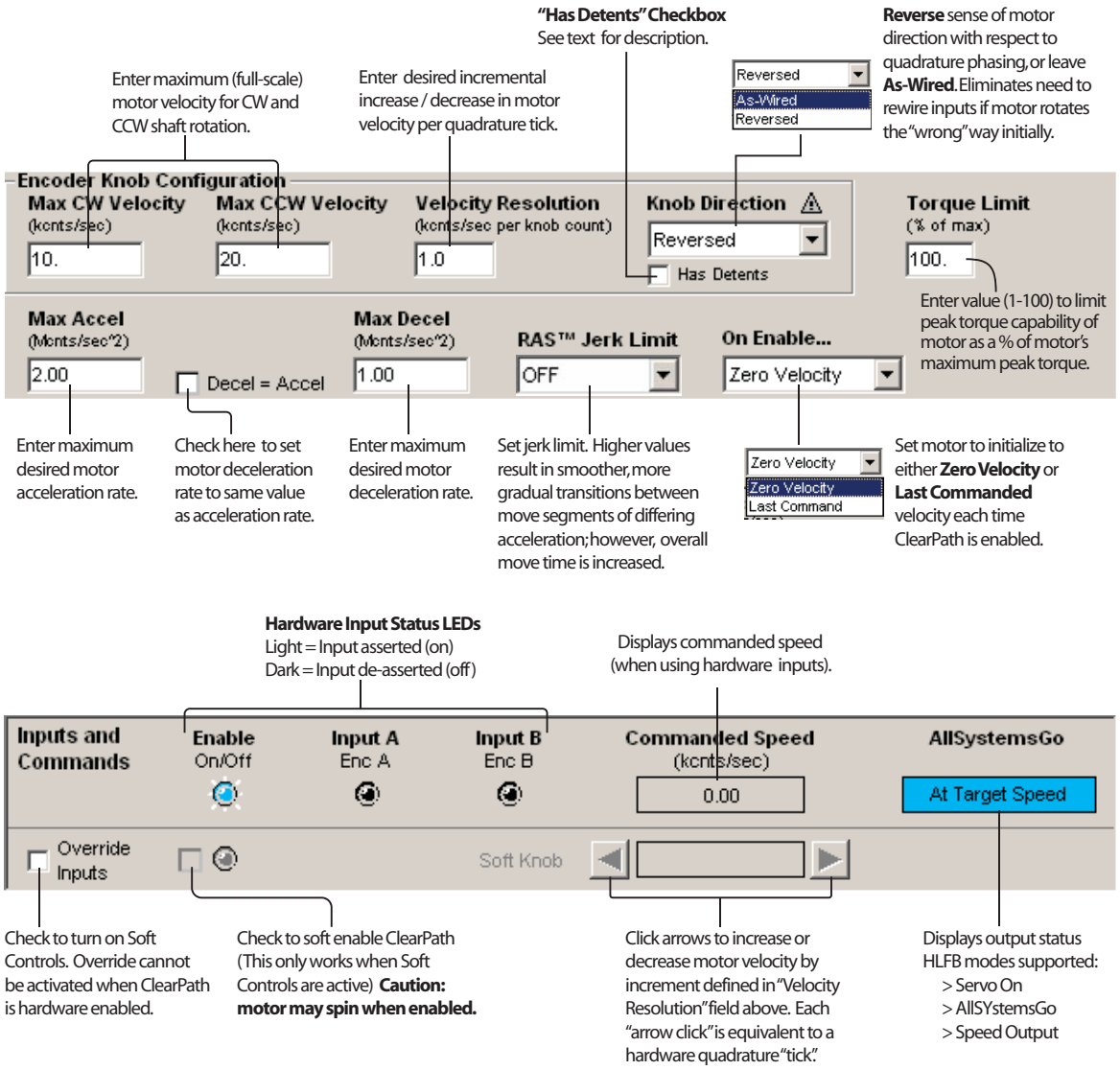
QUADRATURE SIGNAL SOURCE

To use this mode you'll need a device that can generate quadrature signals in the 5-24VDC range. Many users choose an optical or mechanical incremental encoder for this task, but a microcontroller or digital signal generator will work as well. Note: mechanical quadrature encoders are generally the least expensive option.



Quadrature output from a rotary encoder, aka "the knob"

MODE CONTROLS



DESCRIPTION OF ENCODER/KNOB SETTINGS

MAX CW VELOCITY

This setting defines the maximum motor shaft velocity that can be reached when the quadrature knob is turned in the direction that elicits CW shaft rotation.

MAX CCW VELOCITY

This setting defines the maximum shaft velocity that can be reached when the quadrature knob is turned in the direction that elicits CCW shaft rotation.

VELOCITY RESOLUTION

This setting defines exactly how much (i.e., by what increment) motor velocity will increase or decrease per quadrature "tick".

KNOB DIRECTION

These setting allow the user to reverse the motor's sense of direction with respect to the quadrature device.

"HAS DETENTS" CHECKBOX

When unchecked, ClearPath treats each quadrature transition it sees at its inputs as a single "tick". (Remember, each tick causes an incremental increase or decrease in motor speed.)

When checked, ClearPath treats every 4th quadrature transition it sees at its inputs as one "tick". (Remember, each "tick" causes an incremental increase or decrease in motor speed.) Check this box when using an encoder that has one detent point per full quadrature cycle or if you want to divide your quadrature resolution by four.

RAMP UP/DOWN TO SELECTED VELOCITY

MODE SUMMARY

Changing the digital inputs on ClearPath (from your PLC, switches, etc.) causes ClearPath to smoothly ramp to any of four preset velocities.

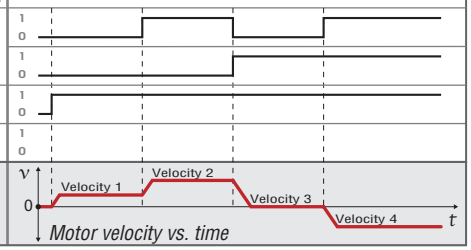
HOW IT WORKS

Assign up to four target velocities where positive values cause CCW motion and negative values cause CW motion.

Assert the Enable Input to start. Once enabled, ClearPath immediately accelerates to the target velocity indicated by the state of Inputs A and B. For example, if Input A=high and Input B=low, ClearPath ramps to "Velocity 2". Change velocity by changing Inputs A and/or B.

Velocity Control **Ramp Up/Down to Selected Velocity (4 Velocity Programmable)**

Signal	Function	Velocity Settings (logic levels)				Example Timing
		Velocity 1	Velocity 2	Velocity 3	Velocity 4	
Input A	Velocity Select A	LOW	HIGH	LOW	HIGH	
Input B	Velocity Select B	LOW	LOW	HIGH	HIGH	
Enable	Enable	Logic: High=Enable Low=Disable				
Trigger	NA	NA				
Tip: Setting one of the programmable velocities to zero (Velocity 3 in the example at right) provides a convenient way to stop the motor via the ClearPath inputs.						

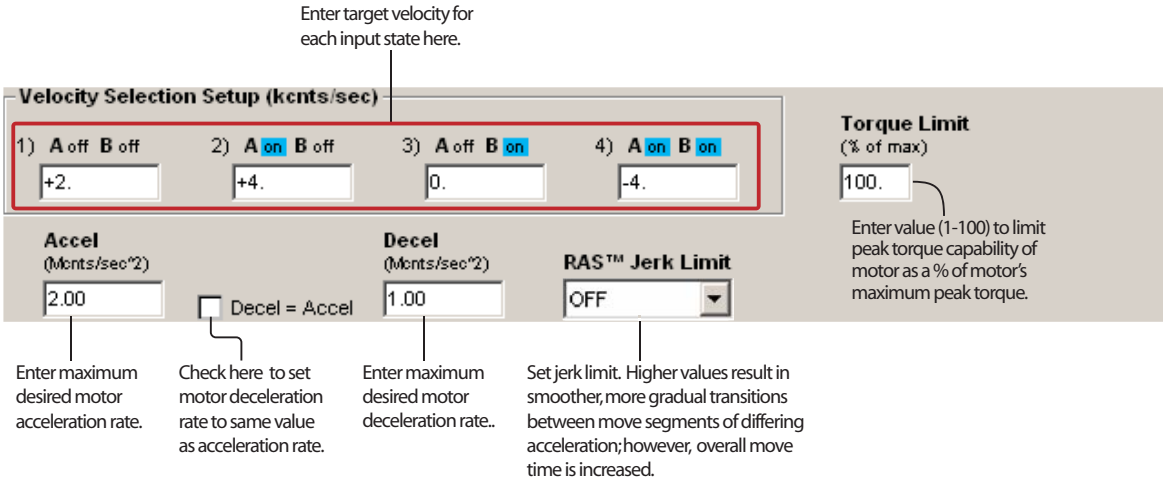


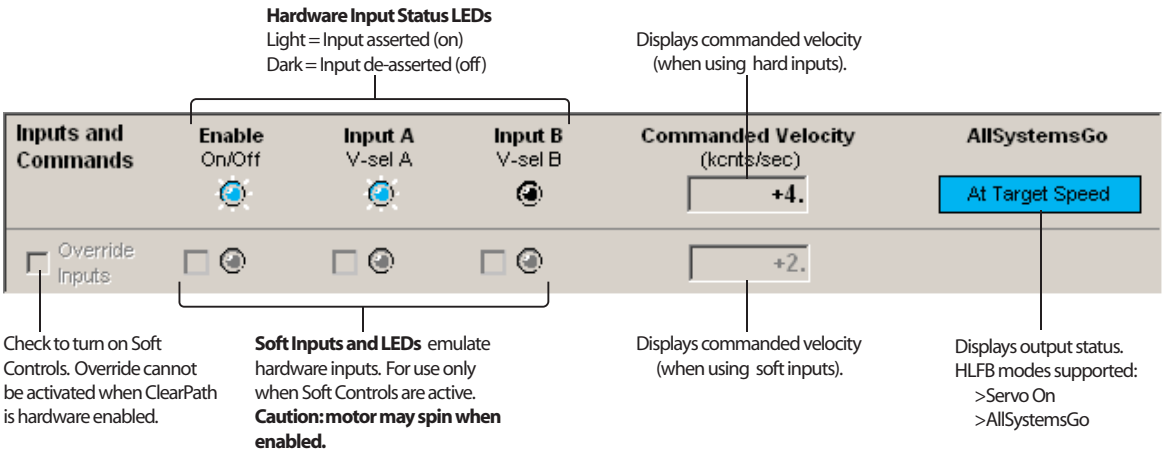
Ramp Up/Down to Selected Velocity Mode: Inputs and Timing Diagram

Notes:

- As soon as a new velocity command is received by ClearPath—as happens when Inputs A and/or B are changed—ClearPath smoothly ramps to the new target velocity without delay.
- If you need a convenient way to command ClearPath to stop via the inputs, set one of the velocity settings to zero. We did this with "Velocity 3" in the table above.
- Disable time = 10 mS

MODE CONTROLS





FOLLOW DIGITAL VELOCITY COMMAND (BI-POLAR PWM INPUT)

MODE SUMMARY

Connect a digital PWM waveform from your PLC or other device, and ClearPath will run at a velocity proportional to the duty cycle of that waveform. Or, use the PWM output from an H-bridge driver of a brushed motor setup and ClearPath becomes a high-performance drop-in replacement.

HOW IT WORKS

Assert the Enable Input to energize the motor. Control motor velocity by applying a PWM signal to Input B. Motor speed and direction change in proportion to the duty cycle of the PWM signal. Assert the Inhibit signal (Input A) to immediately ramp to zero velocity. See figure below and read text for timing and PWM requirements.

Velocity Control **Follow Digital Velocity Command (Bi-Polar PWM Command)**

Signal	Function	Input Type	Example Timing
Input A	Inhibit (optional)	Logic: High=Inhibit on Low=Inhibit off	
Input B	Speed/Direction	Pulse: Variable PWM	
		Duty cycle of applied PWM signal (%)	50% 90% 10%
Enable	Enable	Logic: High=Enable Low=Disable	
Trigger	NA	NA	
Notes: Asserting Inhibit Input causes immediate ramp to zero speed. See text for information on deadband set up and application.			v t Motor velocity vs. time

Inside deadband Inhibit on

Follow Digital Velocity Command (Bi-Polar PWM Control): Inputs and Timing Diagram

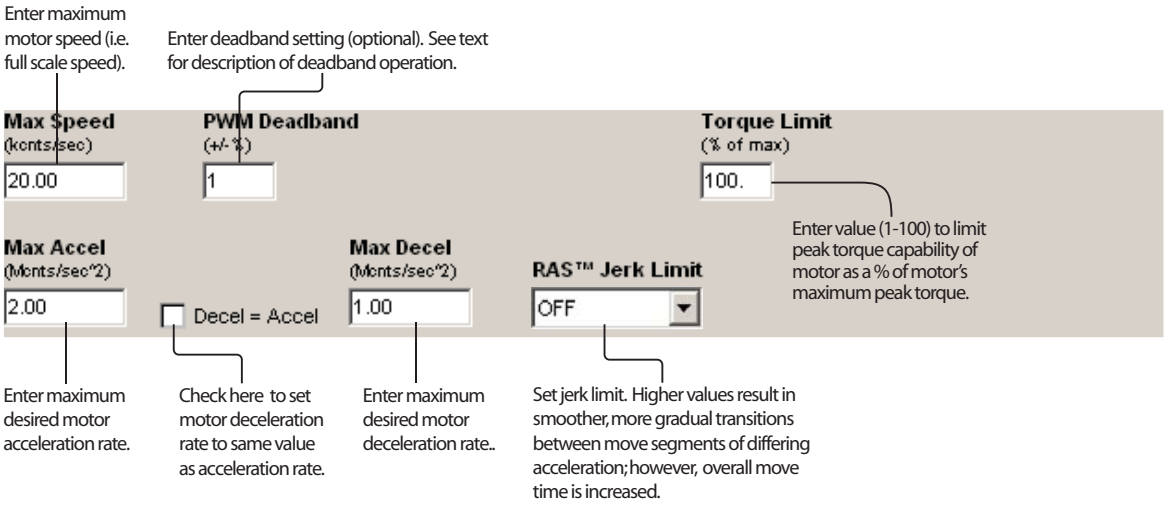
Notes:

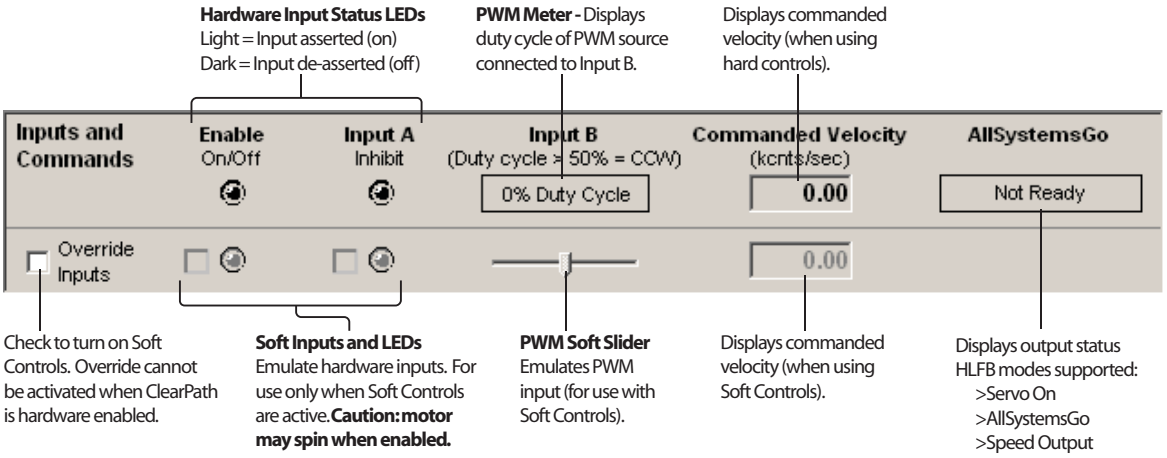
- PWM input frequency range: 20 Hz up to 30 kHz.
- If the PWM signal is off for 50mS or more the PWM input is considered off. This is interpreted by ClearPath as a zero-velocity command.
- Disable time = 10 mS
- Command ClearPath to immediately ramp to zero velocity by asserting the Inhibit Input (Input A). De-assert Input A to resume normal operation.

or

- Set a PWM deadband to help reliably command zero velocity. Read text for details on deadband setup.
- PWM Input, especially at higher frequencies, tends to have more inherent inaccuracy. If a very high level of velocity accuracy is important for your application, consider using Frequency Input mode.

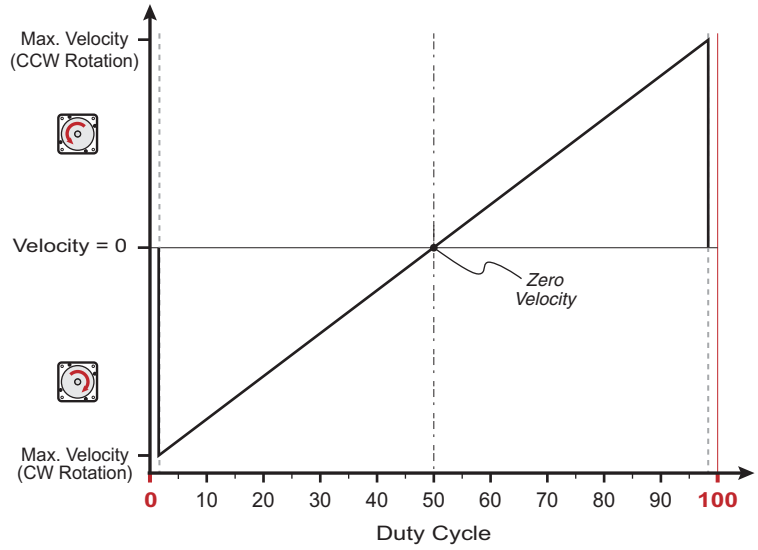
MODE CONTROLS





Relationship of PWM duty cycle to motor velocity

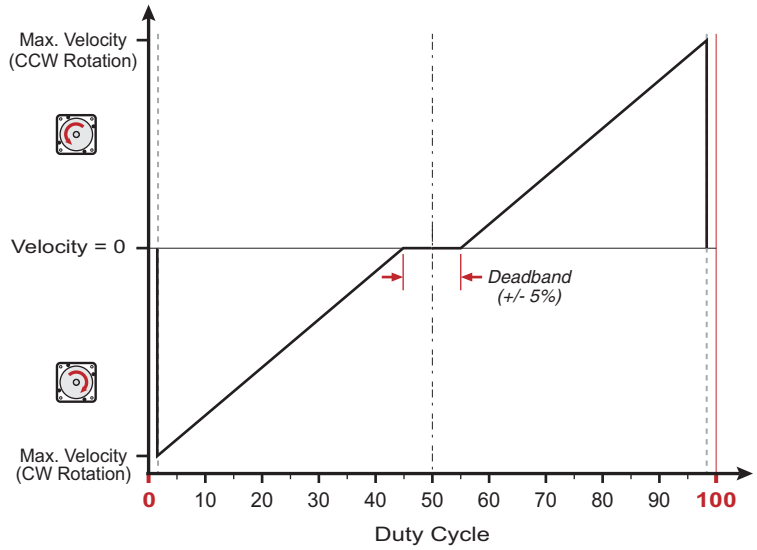
- Shaft velocity increases in the CW direction as PWM duty cycle decreases from 50% to 0%
- Shaft velocity increases in the CCW direction as PWM duty cycle increases from 50% to 100%
- As PWM duty cycle approaches 50%—from either direction—motor velocity approaches 0.
- In practice, O% and 100% (static low and static high conditions) are not valid PWM states. ClearPath treats these cases as zero-velocity commands.
- PWM minimum on time and minimum off time = 300nS.



Graph of PWM duty cycle vs. motor velocity

SETTING A PWM DEADBAND (OPTIONAL)

The deadband expands the range about the 50% PWM mark that is interpreted as the "zero-velocity setting" by ClearPath. This gives the user a reliable way to ensure that motor velocity ramps to zero when the PWM duty cycle is set at (or "close enough" to) 50%.



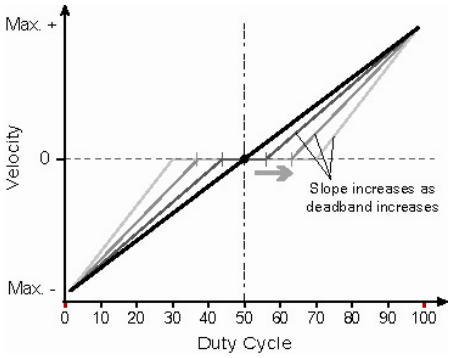
+/- 5% PWM dead band setting

Why use a deadband?

In bi-polar mode, stopping the motor (i.e. commanding "zero velocity") is achieved, in theory, by applying a 50% duty cycle PWM signal to Input B. However, it can be technically challenging to set a perfect 50% duty cycle. In fact, some very low speed motion may still be observed at the motor shaft *even when duty cycle is apparently set to 50%*. A deadband helps to ensure that actual motor velocity is zero (with no drift) when you expect it to be.

Example: If the user sets a +/- 5% dead band, any PWM signal with a duty cycle between 45% and 55% will be interpreted as a zero-velocity command by ClearPath. See figure above.

Note: As size of deadband setting increases, the slope of velocity vs. duty cycle increases as illustrated below.



FOLLOW DIGITAL VELOCITY COMMAND (UNIPOLAR PWM INPUT)

MODE SUMMARY

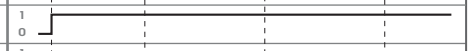
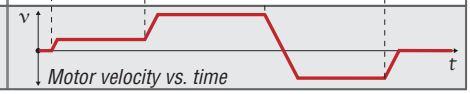
Connect a digital PWM waveform from your PLC or other device, and ClearPath will run at a speed proportional to the duty cycle of the PWM waveform.

HOW IT WORKS

Assert the Enable Input to energize the motor. Once enabled, motor velocity is controlled by sending a PWM signal to Input B. 0% PWM duty cycle commands zero velocity, and 100% (minus a little) duty cycle commands full-scale velocity. Changes in velocity occur at the user-defined acceleration rate.

Direction of travel (CW/CCW) is controlled by the state of Input A. See Inputs and Timing table below.

Velocity Control **Follow Digital Velocity Command (Unipolar PWM Command)**

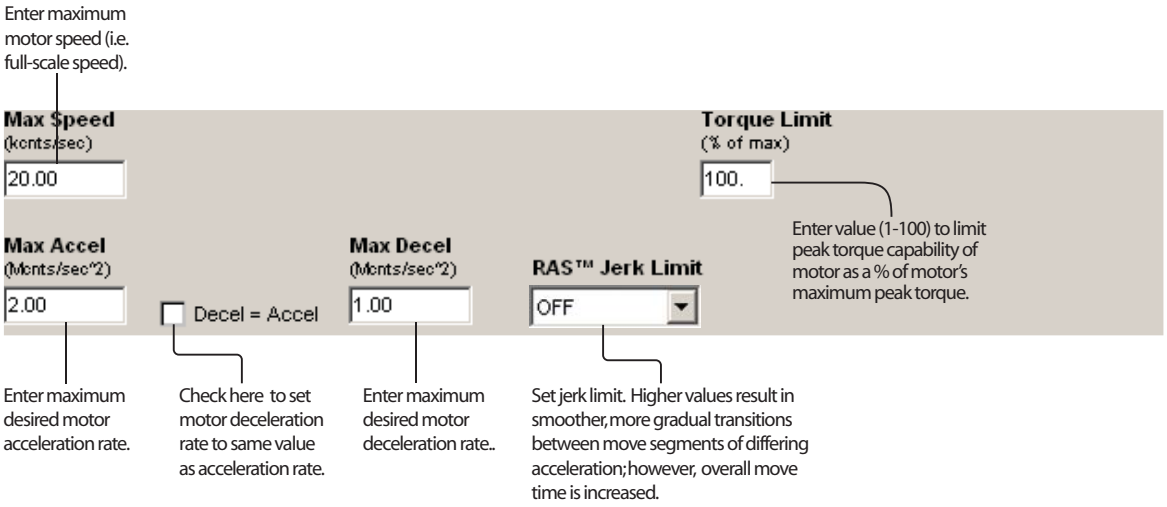
Signal	Function	Input Type	Example Timing
Input A	Direction	Logic: High=CW Low=CCW	
Input B	Velocity	Pulse: Variable PWM	
		Duty cycle of applied PWM signal (%)	
Enable	Enable	Logic: High=Enable Low=Disable	
Trigger	NA	NA	
Notes:			

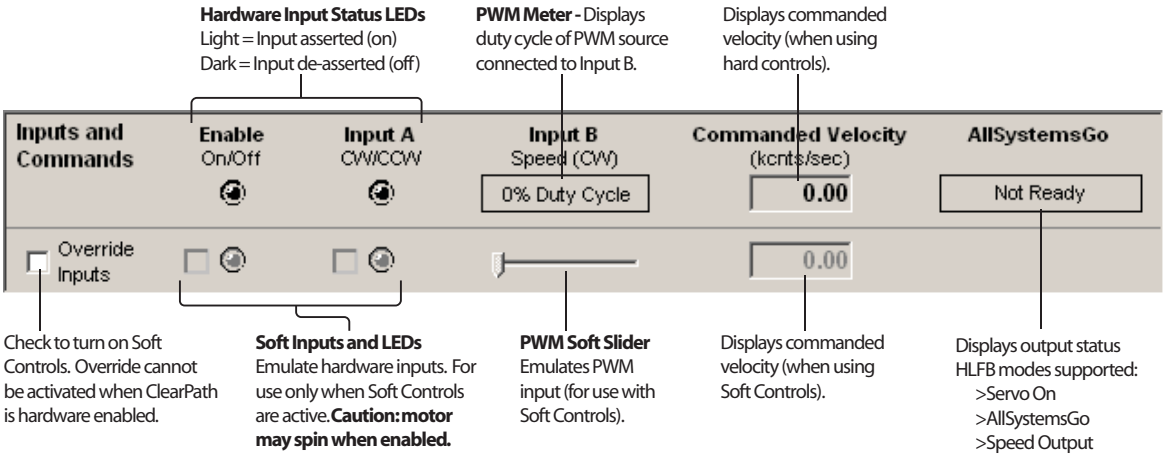
Follow Digital Velocity Command (Unipolar PWM Control): Inputs and Timing Diagram

Notes:

- PWM input frequency range: 20 Hz up to 30 kHz.
- If the PWM signal is off for 50Ms or more the PWM input is considered off. This is interpreted by ClearPath as a zero-torque command.
- Disable time = 10 mS
- PWM Input, especially at higher frequencies, tends to have more inherent inaccuracy. If a very high level of velocity accuracy is important for your application, consider using Frequency Input mode.

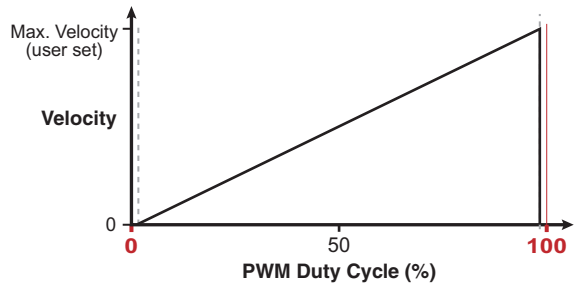
MODE CONTROLS





Motor velocity vs. PWM duty cycle:

- Motor velocity is proportional to PWM duty cycle (velocity increases as duty cycle increases). See figure below.
- In practice, 0% and 100% duty cycle signals (static low and static high respectively) are invalid PWM states, interpreted by ClearPath as "PWM turned off". This is the equivalent of a zero-velocity command.



- For CW shaft rotation, set Input A high. For CCW shaft rotation, set Input A low.
- PWM minimum on time and minimum off time = 300nS

FOLLOW DIGITAL VELOCITY COMMAND (FREQUENCY INPUT)

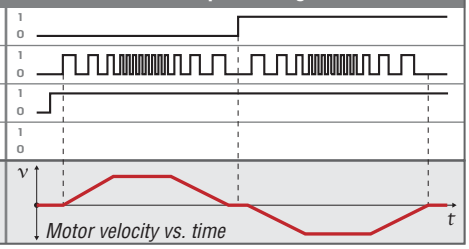
MODE SUMMARY

Connect a digital variable frequency waveform from your PLC or other device, and ClearPath will run at a velocity proportional to the frequency of the waveform.

HOW IT WORKS

Assert the Enable Input to energize the motor. Then, control velocity by applying a variable frequency pulse train to Input B. Pulse frequency is proportional to commanded velocity. Direction of travel (CW/CCW) is controlled by the state of Input A. See Inputs and Timing table below.

Velocity Control **Follow Digital Velocity Command (Frequency Input Control)**

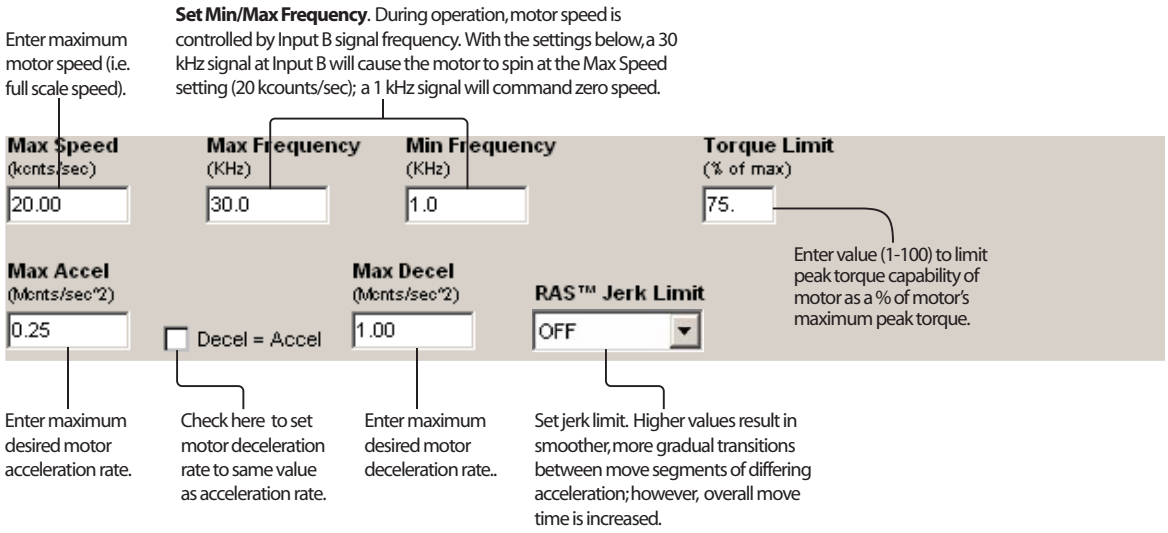
Signal	Function	Input Type	Example Timing
Input A	Direction	Logic: High=CW Low=CCW	
Input B	Velocity	Pulse: Variable Frequency	
Enable	Enable	Logic: High=Enable Low=Disable	
Trigger	NA	NA	
Notes:			

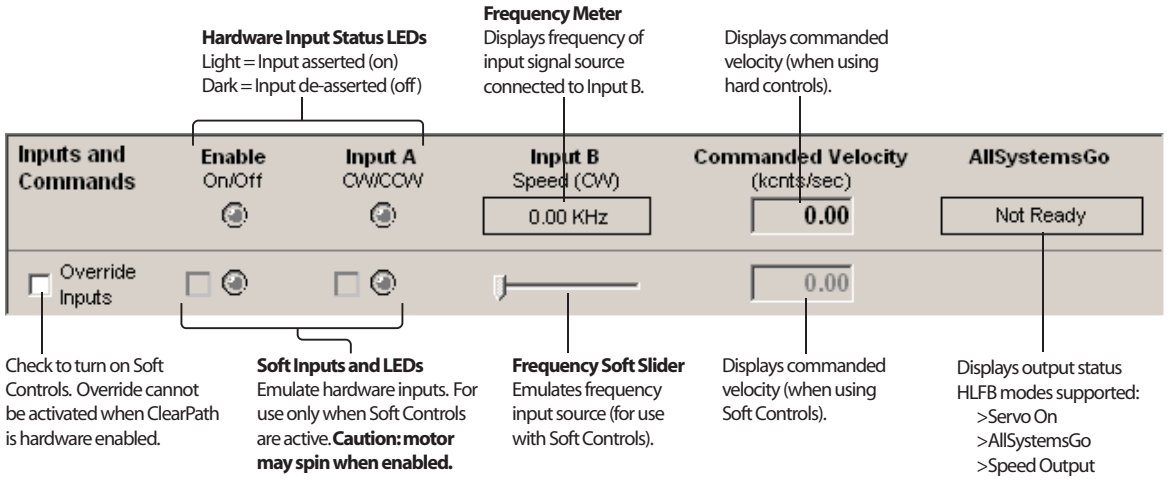
Follow Digital Velocity Command (Frequency Input Control): Inputs and Timing Diagram

Notes:

- Input frequency range: 20 Hz to 500 kHz.
- If the frequency signal is off for 50mS or more the input is considered off. This is interpreted by ClearPath as a zero-velocity command.
- Disable time = 10 mS

MODE CONTROLS





FOLLOW DIGITAL TORQUE COMMAND (BI-POLAR PWM INPUT)

MODE SUMMARY

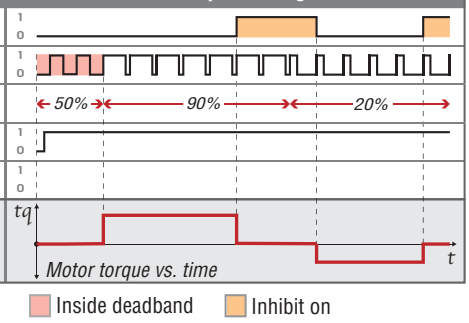
Connect a digital PWM waveform from your PLC or other device, and ClearPath will produce torque proportional to the duty cycle of the PWM waveform.

HOW IT WORKS

Assert the Enable Input to energize the motor. Control motor torque by applying a PWM signal to Input B. Motor torque changes in proportion to the duty cycle of the applied PWM signal. Assert the Inhibit signal (Input A) to immediately turn off torque. See figure below and read text for timing and PWM requirements.

Torque Control **Follow Digital Torque Command (Bi-Polar PWM Command)**

Signal	Function	Input Type	Example Timing
Input A	Inhibit (optional)	Logic: High=Inhibit on Low=Inhibit off	
Input B	Torque/Direction	Pulse: Variable PWM	
		Duty cycle of applied PWM signal (%)	
Enable	Enable	Logic: High=Enable Low=Disable	
Trigger	NA	NA	
Notes: Asserting Inhibit Input causes immediate jump to zero torque. See text for information on deadband set up and application.			



Follow Digital Torque Command (Bi-polar PWM Control): Inputs and Timing Diagram

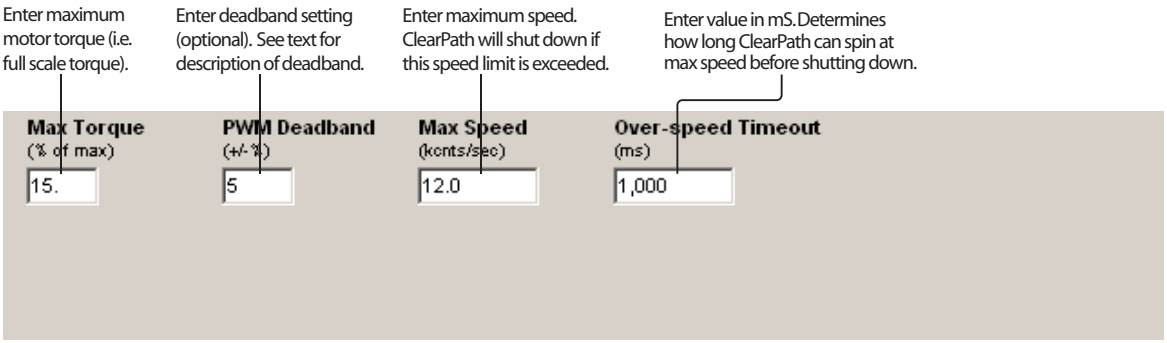
Notes:

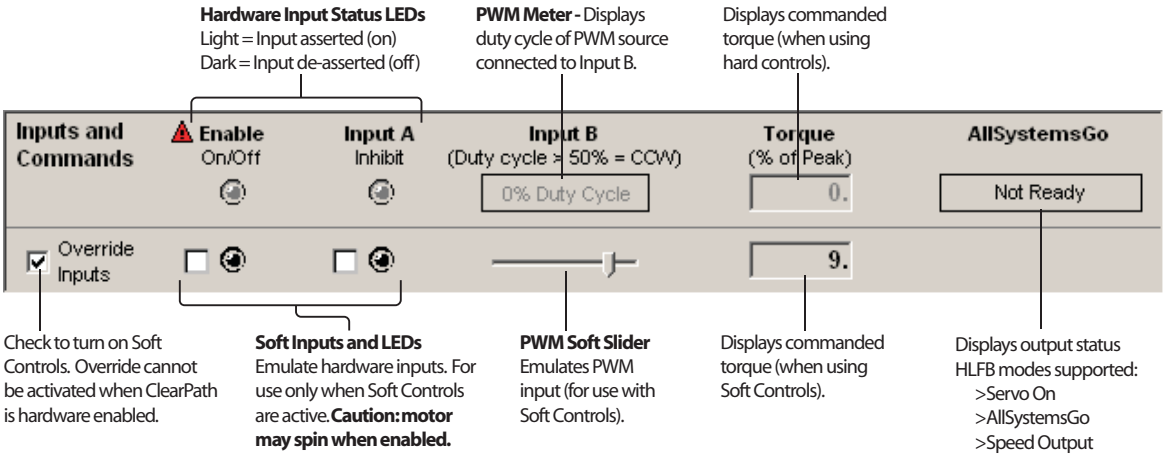
- PWM input frequency range: 20 Hz to 30 kHz.
- If the PWM signal is off for 50mS (or more) the PWM input is considered off. This is interpreted by ClearPath as a zero-torque command.
- Disable time = 10 mS
- To command ClearPath to zero torque, assert the Inhibit Input (Input A). De-assert Input A to resume normal operation.

or

- Set a PWM deadband to help reliably command zero torque. Refer to text on following pages for details on deadband setup.

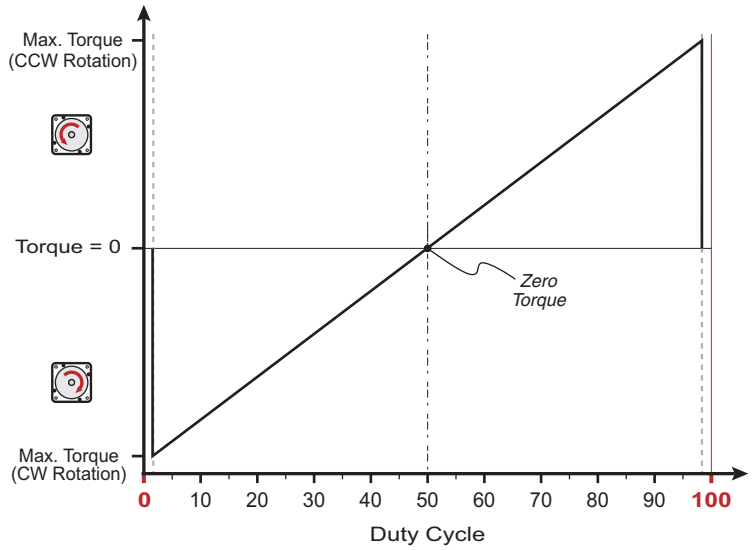
MODE CONTROLS





Relationship of PWM duty cycle to motor torque

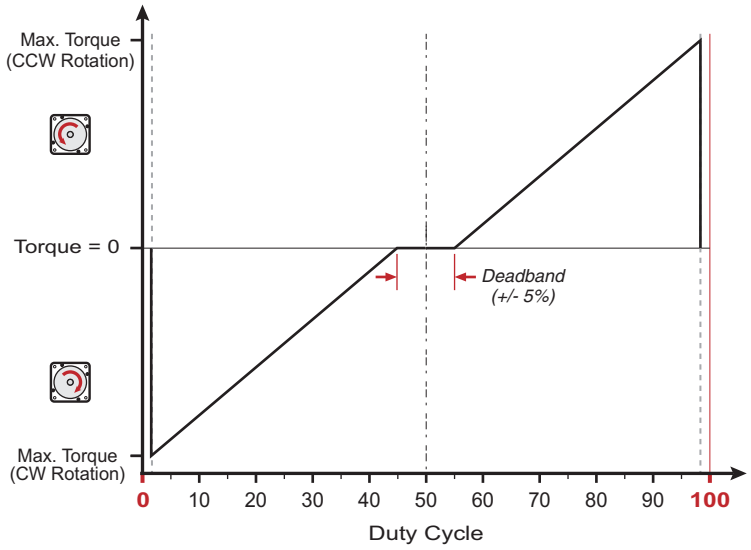
- Shaft torque increases in the CW direction as PWM duty cycle decreases from 50% to 0%.
- Shaft torque increases in the CCW direction as PWM duty cycle increases from 50% to 100%.
- As PWM duty cycle approaches 50% from either direction, motor torque approaches 0.
- O% and 100% duty cycle (static low and static high conditions) are not valid PWM states. ClearPath interprets these values as zero-torque commands.
- PWM minimum on time and minimum off time = 300nS.



PWM duty cycle vs. motor torque

SETTING A PWM DEADBAND (OPTIONAL)

The deadband expands the range about the 50% PWM mark that is interpreted as the "zero torque setting" by ClearPath. This gives the user a reliable way to ensure that motor torque is completely turned off when the PWM duty cycle is set at (or "close enough" to) 50%.



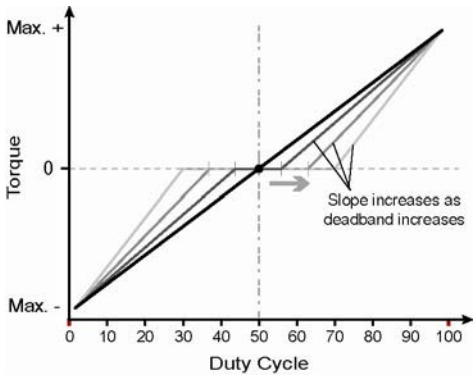
+/- 5% PWM deadband setting

Why use a deadband?

In bi-polar mode, turning off torque is achieved, in theory, by applying a 50% duty cycle PWM signal to Input B. However, it can be difficult to set a perfect 50% duty cycle. In fact, a very small amount of torque may still be produced by the motor, *even when duty cycle is apparently set to 50%*. A deadband helps guarantee torque is fully off when you expect it to be.

Example: If the user sets a +/-5% deadband, any PWM signal with a duty cycle between 45% and 55% (i.e., in the deadband) is interpreted as a zero-torque command by ClearPath.

Note: As deadband setting increases, the slope of torque vs. duty cycle increases as illustrated below.



FOLLOW DIGITAL TORQUE COMMAND (UNIPOLAR PWM INPUT)

MODE SUMMARY

Connect a digital PWM waveform from your PLC or other device, and ClearPath will run at a speed proportional to the duty cycle of the PWM waveform.

HOW IT WORKS

Assert the Enable Input to energize the motor. Motor torque is controlled be applying a variable PWM signal to Input B. 0% PWM duty cycle commands zero torque, and 100% duty cycle commands full-scale torque. Changes in speed occur at the user-defined acceleration rate. Direction of shaft rotation is controlled by the state of Input A. See Inputs and Timing table below.

Torque Control **Variable Torque With Unipolar PWM Input Control**

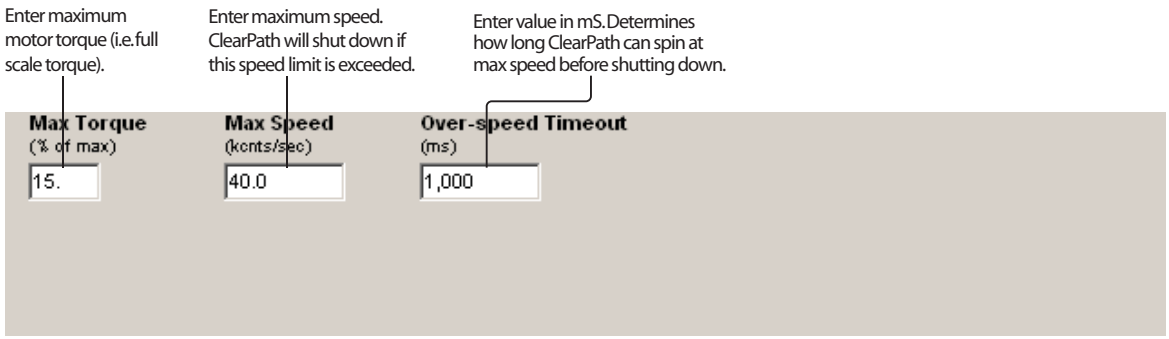
Signal	Function	Input Type	Example Timing
Input A	Direction	Logic: High=CW Low=CCW	
Input B	Torque	Pulse: Variable PWM	
		Duty cycle of applied PWM signal (%)	*10% 90% OFF*
Enable	Enable	Logic: High=Enable Low=Disable	
Trigger	NA	NA	
Notes:			*tq* *t* *Motor torque vs. time*

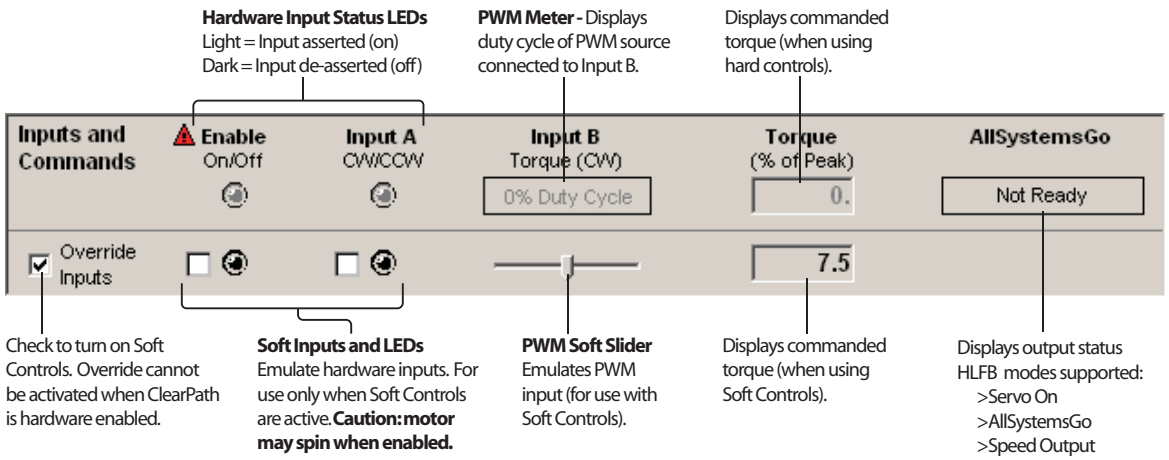
Variable Torque Mode (Unipolar PWM Control): Inputs and Timing Diagram

Notes:

- PWM input frequency range: 20 Hz to 30 kHz.
- If the PWM signal is off for 50mS (or more) the PWM input is considered off. This is interpreted by ClearPath as a zero-torque command.
- Disable time = 10 mS

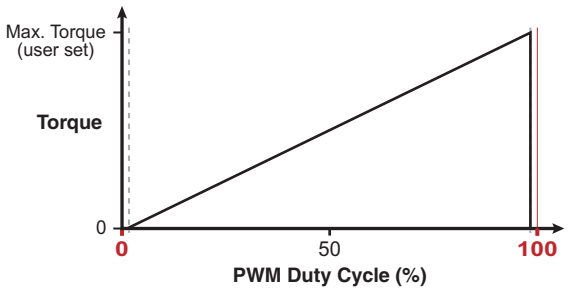
MODE CONTROLS





Motor torque vs. PWM duty cycle:

- Motor torque is proportional to PWM duty cycle (i.e. torque increases as duty cycle increases). See figure below.
- 0% and 100% duty cycle signals (static low and static high respectively) are invalid PWM states, interpreted by ClearPath as "PWM turned off". This is the equivalent of a zero-torque command.



PWM duty cycle vs. torque

- For CW torque, set Input A high. For CCW torque, set Input A low.
- PWM minimum on time and minimum off time = 300nS

FOLLOW DIGITAL TORQUE COMMAND (FREQUENCY INPUT)

MODE SUMMARY

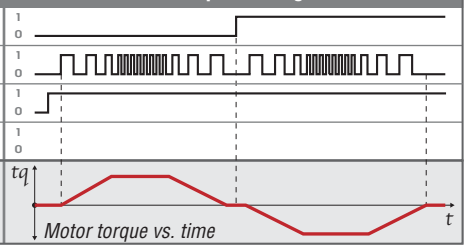
Connect a digital variable frequency waveform from your PLC or other device, and ClearPath will produce torque that is proportional to the frequency of the waveform.

HOW IT WORKS

Assert the Enable Input to energize the motor. Control torque by applying a variable frequency pulse train to Input B. Pulse frequency is proportional to commanded torque. Direction in which torque is applied (CW/CCW) is controlled by the state of Input A. See Inputs and Timing table below.

Torque Control **Variable Torque With Frequency Input Control**

Signal	Function	Input Type	Example Timing
Input A	Direction	Logic: High=CW Low=CCW	
Input B	Torque	Pulse: Variable Frequency	
Enable	Enable	Logic: High=Enable Low=Disable	
Trigger	NA	NA	
Notes:			

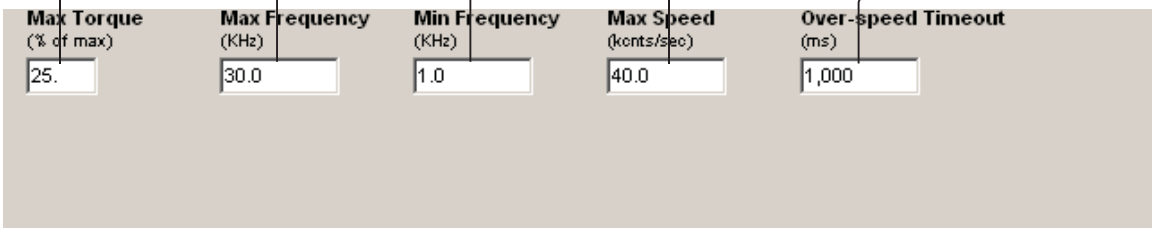


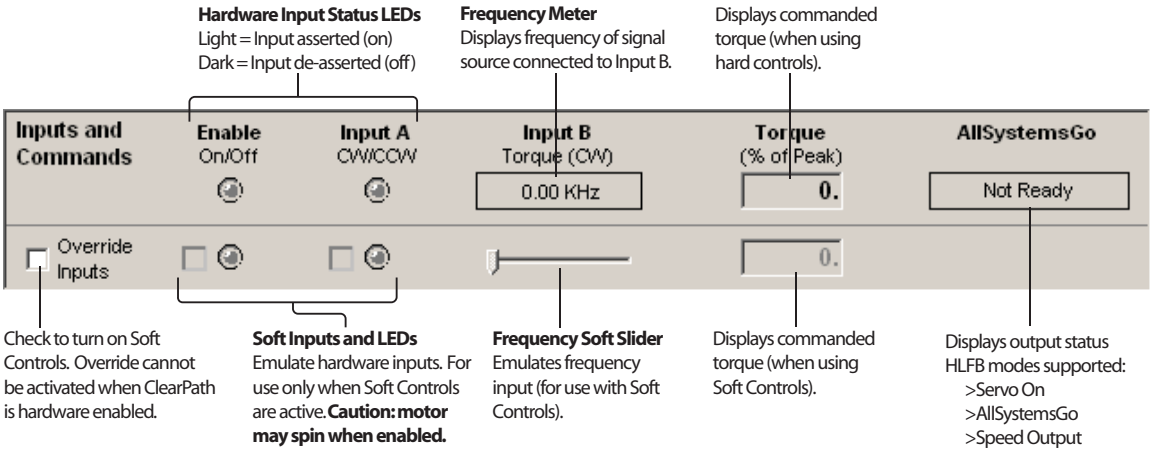
Variable Torque Mode (Frequency Control): Inputs and Timing Diagram

Notes:

- Input frequency range: 20 Hz to 500 kHz.
- If the frequency signal is off for 50mS or more the input is considered off. This is interpreted by ClearPath as a zero-torque command.
- Disable time = 10 mS

MODE CONTROLS





MOVE TO ABSOLUTE POSITION (2-POSITION)

MODE SUMMARY

Trigger ClearPath to move to one of two preset locations. This mode was designed for replacing hydraulic or pneumatic cylinders that move between two positions.

HOW IT WORKS.

Assert the Enable Input to energize the motor. Once enabled, ClearPath automatically executes a homing move to a [user-supplied] switch or sensor wired to Input B. Once a home position is established, ClearPath automatically moves to one of the two user-defined positions (based on the state of Input A). After that, just toggle Input A to move between the two target positions.

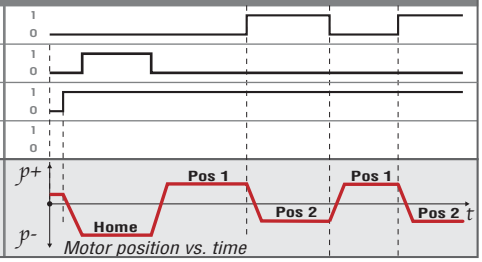
Absolute Position

An absolute position is referenced to an established "home" position. Your target positions, in this context, are defined in terms of *distance from the home position*. For example, Position 1 could be defined as 5200 encoder counts from home, while Position 2 might be defined as 2000 encoder counts from home.

Position Control **Absolute Position (2-Position Programmable)**

Signal	Function	Input Type	Example Timing
Input A	Position Select	Logic: High=Pos. 2 Low=Pos. 1	
Input B	Home Switch	Logic: High=Home Low= Not Home	
Enable	Enable	Logic: High=Enable Low=Disable	
Trigger	NA	NA	

Notes: ClearPath must home to a switch upon enable to establish the Home (zero) position to which the other target positions are referenced.

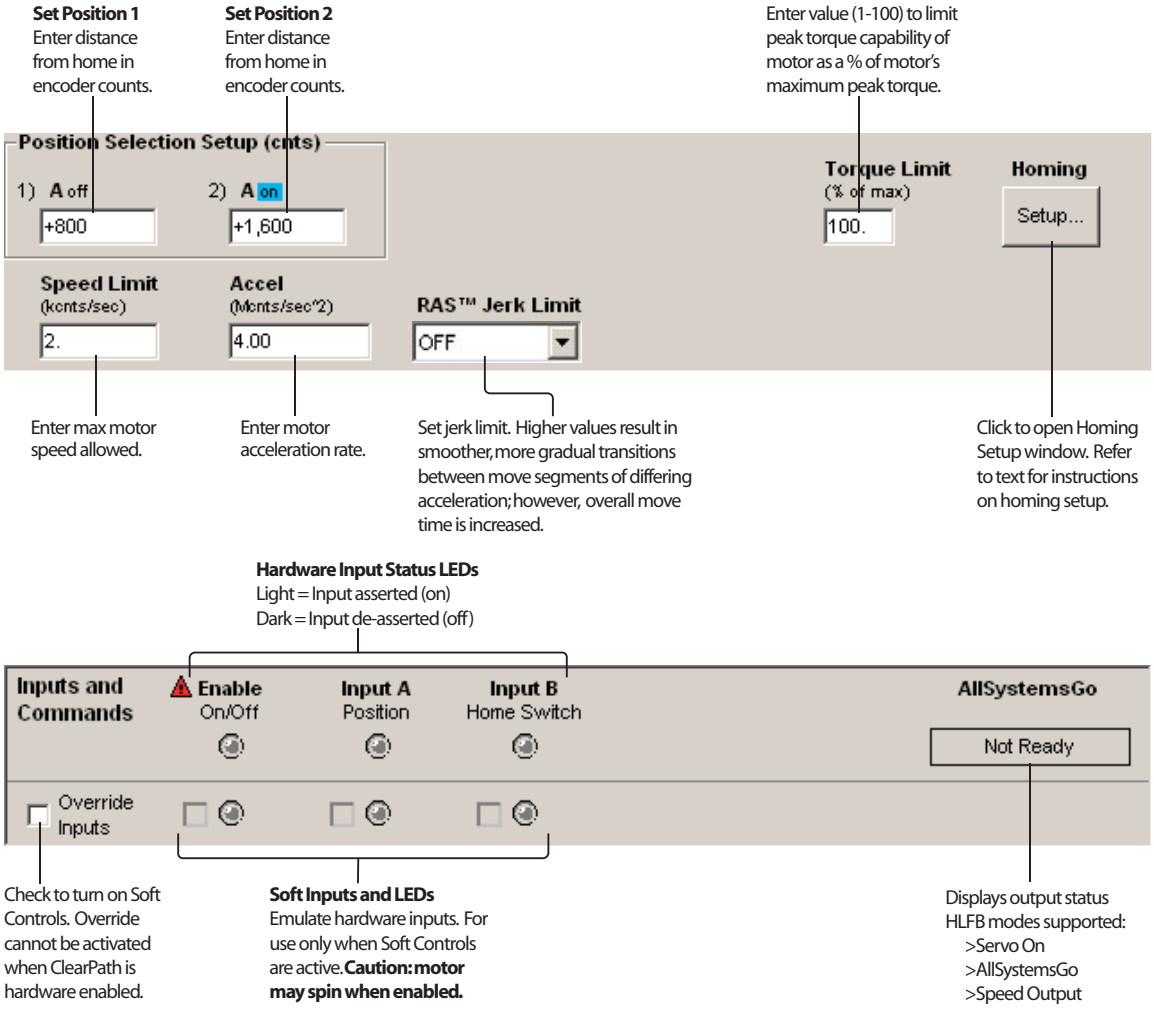


Absolute Position Mode (2): Inputs and Timing Diagram

Notes:

- If the state of Input A is changed during a move, ClearPath will immediately ramp to a stop and move to the newly indicated position.
- Input B switch polarity can be inverted via a checkbox in the Homing Setup dialog. When home switch polarity is inverted, ClearPath interprets Input B-low as "in the home switch", and Input B-high as "not in the home switch".
- Disable time = 10 mS

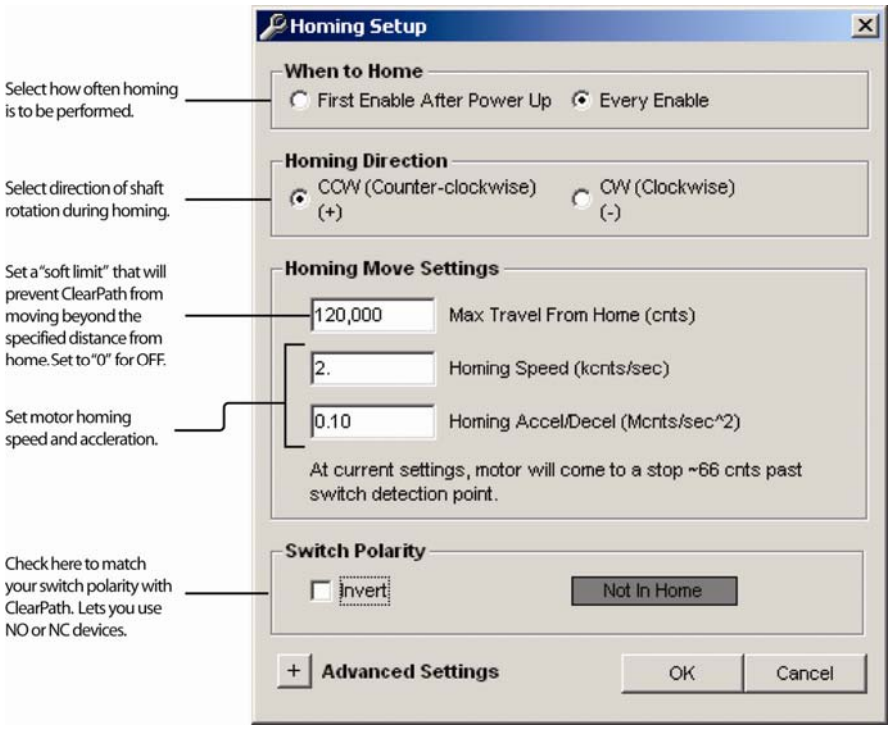
MODE CONTROLS



HOMING SETUP (HOME-TO-SWITCH)

Homing is required in this mode. Follow the instructions below to set up switch homing.

1. Securely fasten a limit switch or sensor to one end of the motion axis and wire it to Input B.
2. Click the Setup button to open the homing dialog.
3. Enter homing parameters. See figure next page for description of homing parameters.



Homing setup dialog

4. Test and modify your homing setup for proper performance.

How Switch Homing Works:

- During homing, the axis is automatically driven toward the homing switch at the user-specified direction and speed.
- Once the switch is actuated, the motor ramps to a stop and the encoder position counter is zeroed. This position is now considered the home reference position.

MOVE TO ABSOLUTE POSITION (4-POSITION)

MODE SUMMARY

Command ClearPath to move to one of four preset locations. Perfect for replacing air cylinders in scenarios where more power and/or finesse are needed (and you want to position at more than just two locations).

Absolute Position

An absolute position is referenced to an established "home" position. Your target positions, in this context, are defined in terms of *distance from the home position*. For example, Position 1 might be defined as 2000 encoder counts from home, while Position 2 might be defined as 5200 encoder counts from home.

HOW IT WORKS

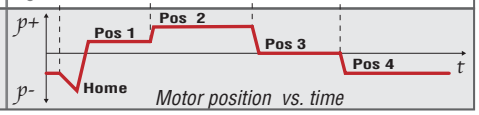
Assert the Enable Input to energize the motor. Once enabled ClearPath automatically homes to a hard stop to establish an absolute home reference position. Note: Homing is required in this mode.

After homing, ClearPath can be commanded to move to any of four user-defined positions by changing the state of Input A and B. Changing these inputs has the dual effect of selecting target position, and triggering the move. See table below for timing and input details. All moves execute at the user-defined speed and acceleration.

Position Control **Absolute Positioning (4-Position Programmable)**

Signal	Function	Position Settings				Example Timing
		Pos. 1	Pos. 2	Pos. 3	Pos. 4	
Input A	Position Select A	LOW	HIGH	LOW	HIGH	
Input B	Position Select B	LOW	LOW	HIGH	HIGH	
Enable	Enable	Logic: High=Enable Low=Disable				
Trigger	NA	NA				

Notes: ClearPath must home to a "hard stop" (either upon first enable or upon every enable) to establish a home reference position. All user-defined target positions are referenced to the home position.

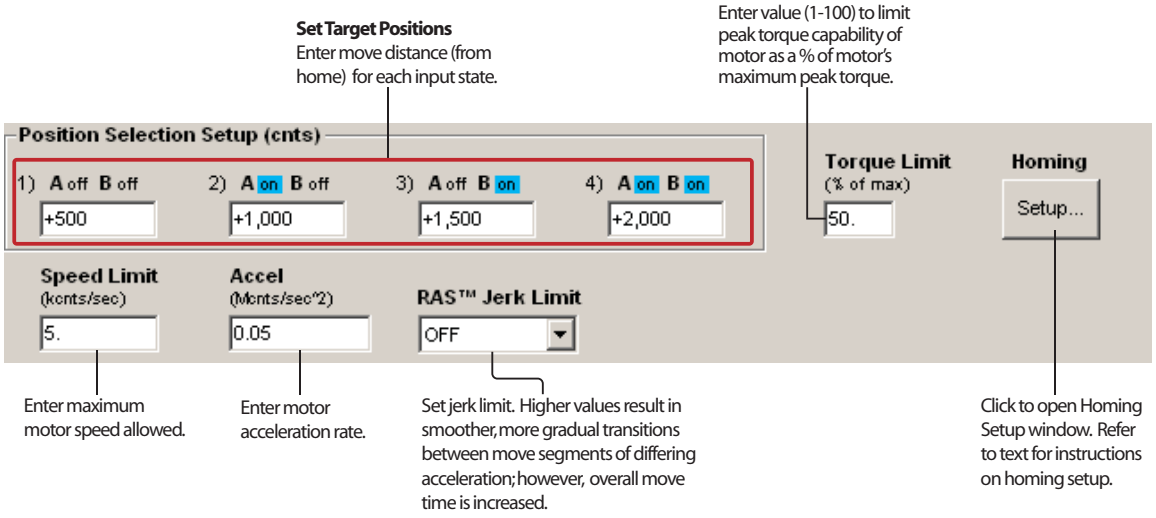


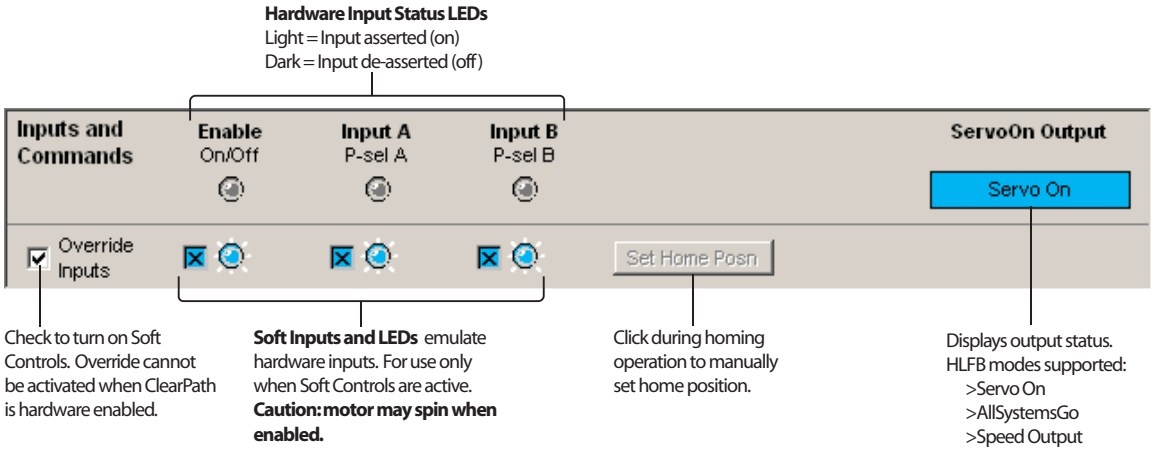
Absolute Position Mode (4-position): Inputs and Timing Diagram

Notes:

- Changing the state of Input A and/or B while ClearPath is in motion cancels the move in progress. ClearPath immediately ramps to a stop and initiates a new move to the newly indicated target position.
- Disable time = 10 mS

MODE CONTROLS

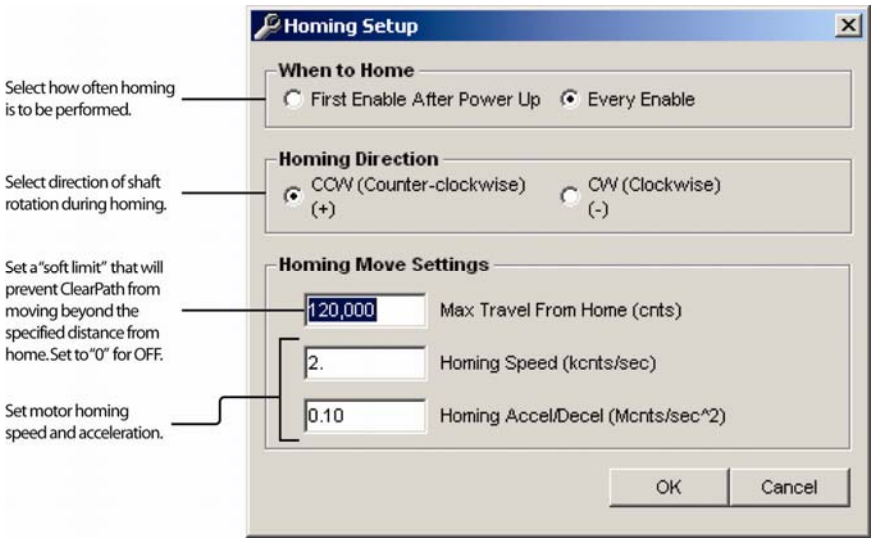




HOMING SETUP (HARD STOP HOMING)

In this mode, ClearPath *must* home to a hard stop to establish a home reference position before functional positioning can begin.

1. Install a hard stop that guarantees the moving element of the axis will make solid, repeatable contact with the stationary element when driven into it.
2. Click the Setup button to open the homing dialog.
3. Enter homing parameters. See figure next page for description of homing parameters.



Homing setup dialog

4. Test and modify your homing setup for consistent, repeatable performance.

MOVE TO SENSOR POSITION

MODE SUMMARY

Use ClearPath digital inputs to spin the shaft CW or CCW. Wire position sensors and switches in series with ClearPath inputs to make an inexpensive two position actuator.

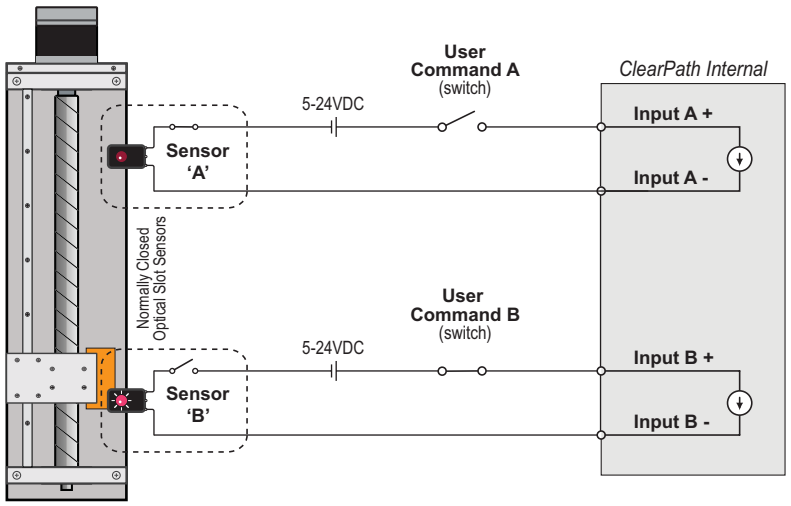
HOW IT WORKS.

Place sensors at opposite ends of your motion path and wire them into the appropriate ClearPath inputs. See illustration below.

Assert the Enable Input to energize the motor. Apply User Commands to start motion. ClearPath moves CW or CCW until it interrupts a sensor. It then holds position until you issue a new User Command in the opposing direction. See table below for Input states and timing details.

Position Control **Move to Sensor Position**

Signal	Function	Example Timing
User Command A	Wired in series with Input A	
Sensor A	Wired in series with Input A	
Input A	**CW Move Request**	
User Command B	Wired in series with Input B	
Sensor B	Wired in series with Input B	
Input B	**CCW Move Request**	
Enable	**Enable:** High=Enable Low=Disable	
		v, CCW, CW — *Motor velocity vs. time*

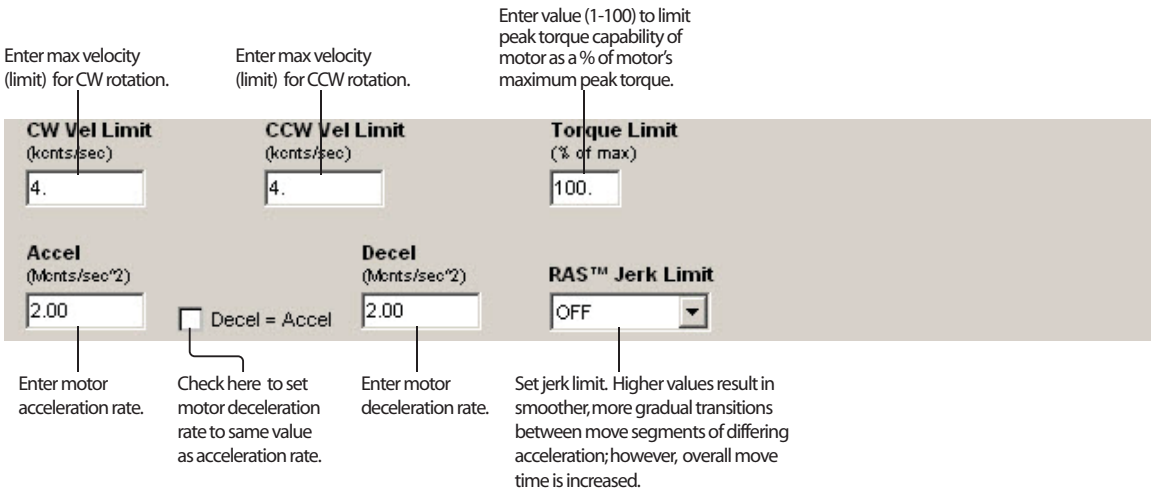


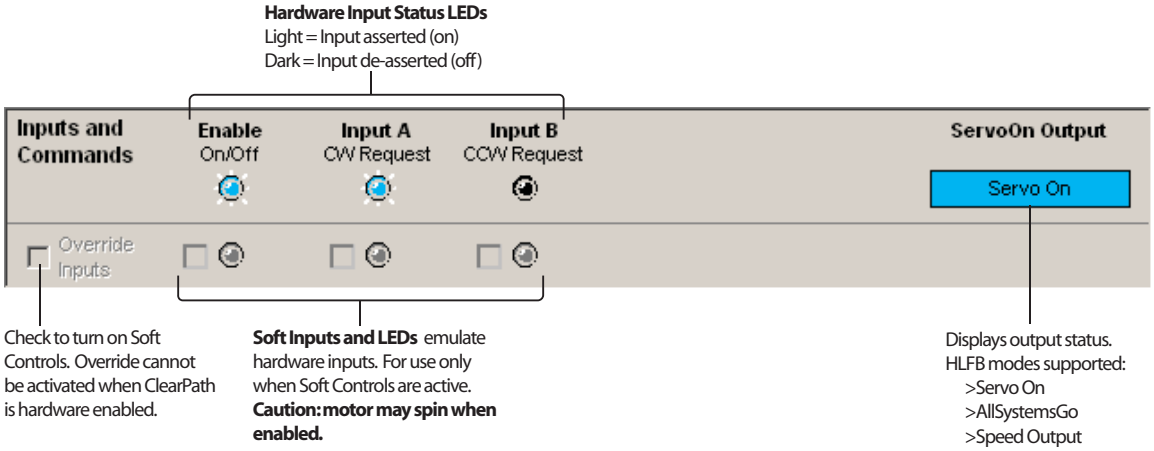
Move to Sensor: Inputs and Timing Diagram with example application sketch

Notes:

- **Stay in between the sensors.** When using an optical slot type sensor, the "flag" must be long enough to continuously interrupt the sensor from the start of deceleration through full stop. In addition, the deceleration rate must be set to ensure that the flag does not travel past the sensor.
- Changing the state of either Input A or Input B while ClearPath is in motion effectively cancels the move in progress. ClearPath immediately ramps to a stop and holds position until a new move request[3] is received.
- Disable time = 10 mS

MODE CONTROLS





[3] In this scenario, the next move request must be in the opposite direction from the previous move request. Thus, if the motor was spinning in the CW direction when the move was canceled, ClearPath will only respond to a CCW move request.

MOVE INCREMENTAL DISTANCE (2-DISTANCE)

MODE SUMMARY

Send a trigger pulse to tell ClearPath to move a user-defined distance from its current position. Send multiple, quick trigger pulses to tell ClearPath to travel a multiple of any distance in one smooth, uninterrupted move.

Incremental Positioning

An incremental move is referenced to its own starting position, not to an absolute "home" reference position. So, if the incremental move distance is set to +1000 counts, the shaft will move +1000 counts from its current position each time a trigger pulse is received.

HOW IT WORKS

Assert the Enable Input to energize the motor. ClearPath can be set to perform an optional homing routine (home-to-switch only in this mode). Incremental move distance is selected with Input A. Pulsing the Enable/Trigger Input launches each move.

Position Control **Incremental Positioning (2 Incremental Distances)**

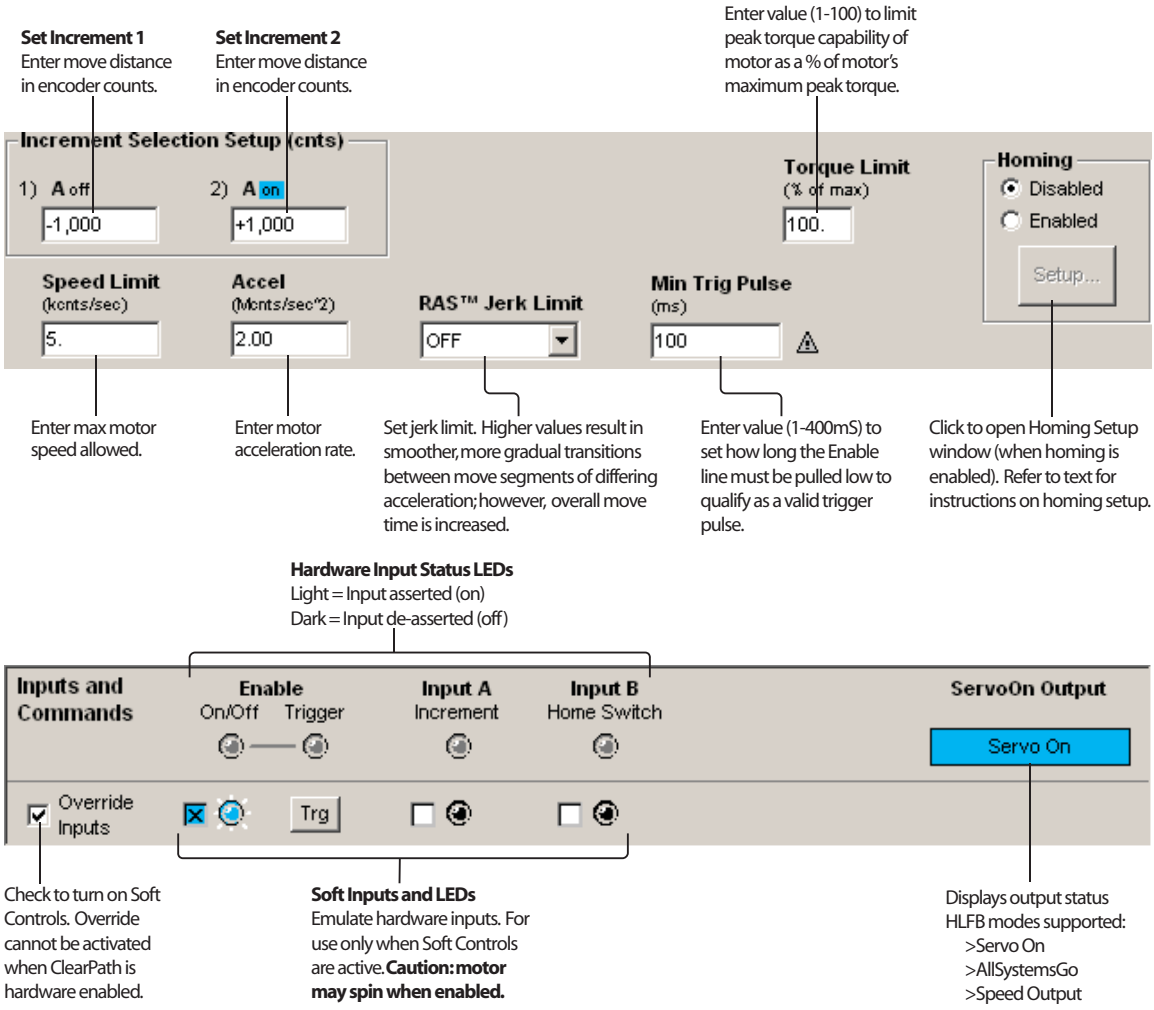
Signal	Function	Input Type	Example Timing
Input A	Increment Select	Logic: Low=Dist.1 High=Dist. 2	
Input B	Home Switch (optional)	Logic: High=Home Low= Not Home	
Enable/ Trigger	Enable Trigger	Logic: High=Enable Low=Disable Pulse Enable line low to trigger moves	
Notes: ClearPath can be programmed to home upon enable (see text for full details). Moves are triggered on rising edge of trigger pulse.			p+ p- Home D2 D2 D2 D1 D1 t Motor position vs. time Trigger pulse

Incremental Position Mode: Inputs and Timing Diagram

Notes:

- A trigger pulse is required to launch each incremental move. Move distance is selected with Input A.
- To create a longer continuous move, you can send multiple trigger pulses and ClearPath will automatically "chain" the move increments together to form a single seamless move. Note: To successfully "chain" move increments, the burst of trigger pulses must be sent rapidly. They must be received by the ClearPath during the acceleration through constant velocity portion of move, *but not during the deceleration phase*. If a trigger pulse is received during the deceleration phase of a move, that move will run to completion (motor will stop). Then the next incremental move will execute.

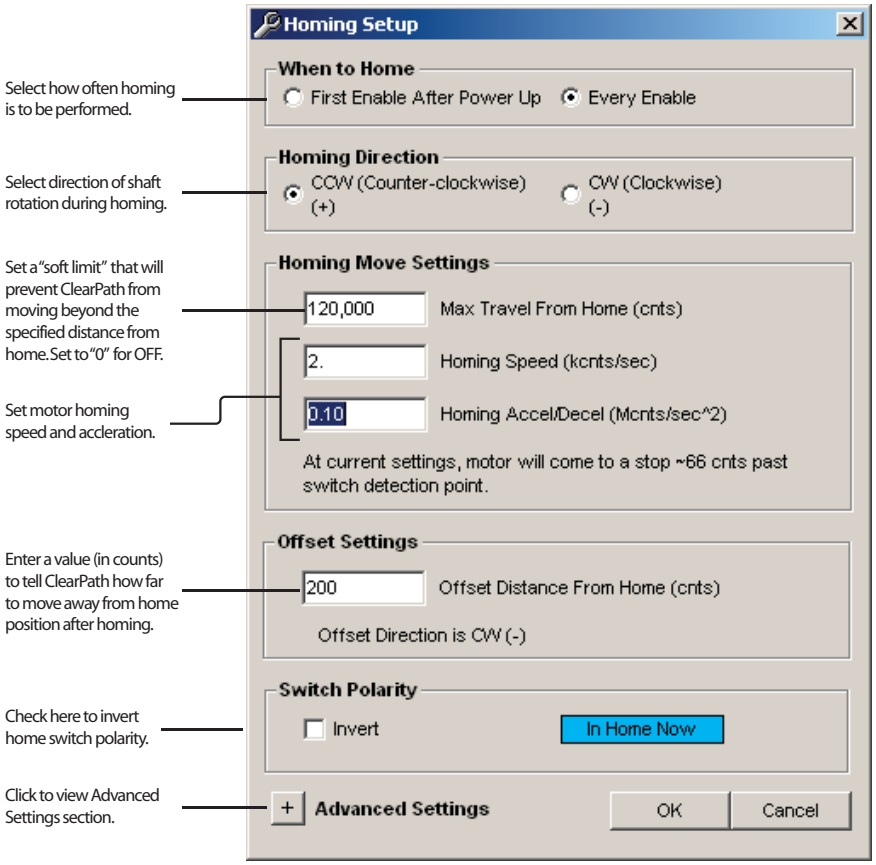
MODE CONTROLS



HOMING SETUP (HOME-TO-SWITCH)

This mode supports optional home-to-switch functionality. When homing is initiated, the motor automatically rotates at the user-specified speed, acceleration, and direction until a switch or sensor is actuated. Then ClearPath sets the home position (a settable homing offset is optional). See homing setup instructions below.

STANDARD SETTINGS



Homing: Standard Settings

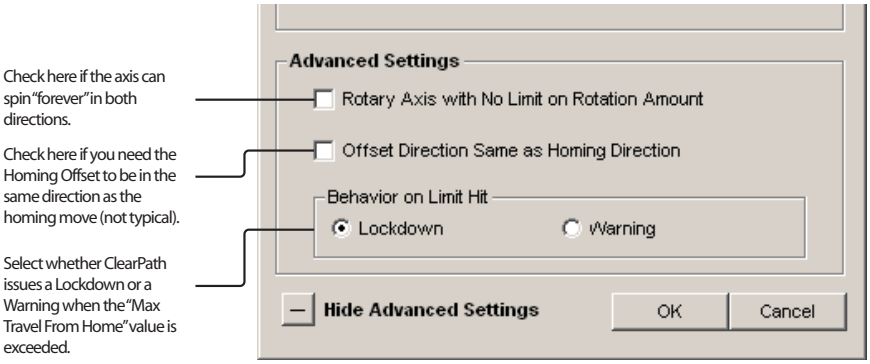
1. Install a compatible switch or sensor at one end of travel and wire it to Input B. Note: To work properly, the switch or sensor must be placed at the end of travel. Refer to I/O section (earlier in this document) for switch/sensor wiring information.
2. In MSP, enable homing and click Setup to open the homing setup dialog (shown above).
3. **When to Home.** Choose to perform a homing sequence either 1) the first time ClearPath is enabled or 2) every time ClearPath is enabled.
4. **Homing Direction.** Choose clockwise or counter-clockwise shaft rotation during homing.
5. **Homing Move Settings.**

a. Set **Homing Speed** and **Homing Accel/Decel**.

b. Enter **Max Travel From Home.** This is maximum distance from the home position (in counts) that ClearPath can be commanded to move. Note: ClearPath will not execute a move that would violate this limit. See Advanced Settings, *Behavior on Limit Hit*, below for additional settings related to this feature.

6. **Switch Polarity.** Use this checkbox to change whether Input B (the home sensor input) must be high or low to be considered asserted.

ADVANCED SETTINGS



Homing: Advanced Settings

Rotary Setting with No Limit on Rotation Amount

Check this box if you have an axis such as a conveyor or turntable that can turn in either direction forever.

Offset Direction Same as Homing Direction

Check this box if you want the post-homing offset move to be in the same direction as the homing move. This setting is mainly used with rotary axes with unlimited bi-directional motion such as a turntable or conveyor.

Behavior on Limit Hit

This setting tells ClearPath whether to issue a Warning or a Lockdown if you attempt to move past the "Max Travel from Home" soft limit setting (see Standard Settings on previous page for description of Max Travel from Home).

Warning vs. Lockdown

- **A Lockdown** disallows motion. You must to toggle Enable to clear a Lockdown. The indicator LED on ClearPath flashes alternating yellow and green when a Lockdown occurs.
- **A Warning** allows motion only in the direction away from the soft limit and the warning automatically clears itself when the reason for the Warning is no longer present. The indicator LED on ClearPath flashes a green 2-blink code when a Warning occurs.

MOVE INCREMENTAL DISTANCE (4-DISTANCE)

MODE SUMMARY

Send a trigger pulse to tell ClearPath to move a user-defined distance [increment] from its current position. Send multiple, quick trigger pulses to tell ClearPath to travel a multiple of any distance in one smooth, uninterrupted move.

Incremental Positioning

An incremental move is referenced to its own starting position, not to an absolute "home" reference position. So, if the incremental move distance is set to +1000 counts, the shaft will move +1000 counts from its current position each time a trigger pulse is received.

HOW IT WORKS

Assert the Enable Input to energize the motor. ClearPath can be set to perform an optional homing routine (home-to-hard stop only in this mode). Move distance is selected with Inputs A and B. Pulsing the Enable/Trigger Input launches each move.

Position Control **Incremental Positioning (4-Distance Programmable)**

Signal	Function	Incremental Distance Settings				Example Timing
		Dist.1	Dist.2	Dist.3	Dist.4	
Input A	Increment Select A	LOW	HIGH	LOW	HIGH	
Input B	Increment Select B	LOW	LOW	HIGH	HIGH	
Enable/ Trigger	Enable Trigger	Logic: High=Enable Low=Disable Pulse Enable line to trigger moves				
Notes: ClearPath can be programmed to home upon enable (see text for full details). Moves are triggered on rising edge of trigger pulse.						p+ D1 D2 D3 D4 D1 D1 D2 D2 t p- Motor position vs. time

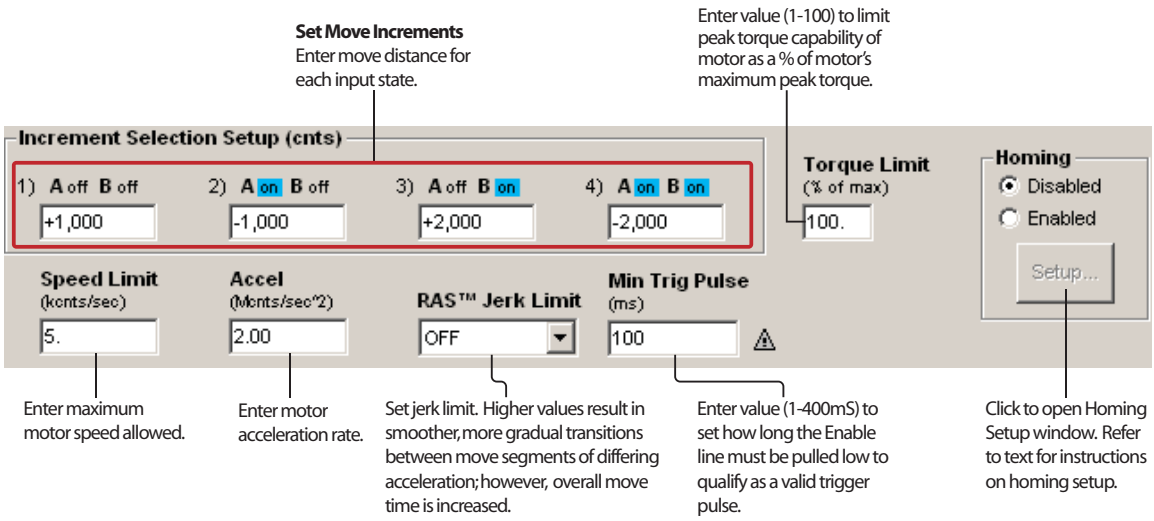
Trigger pulse

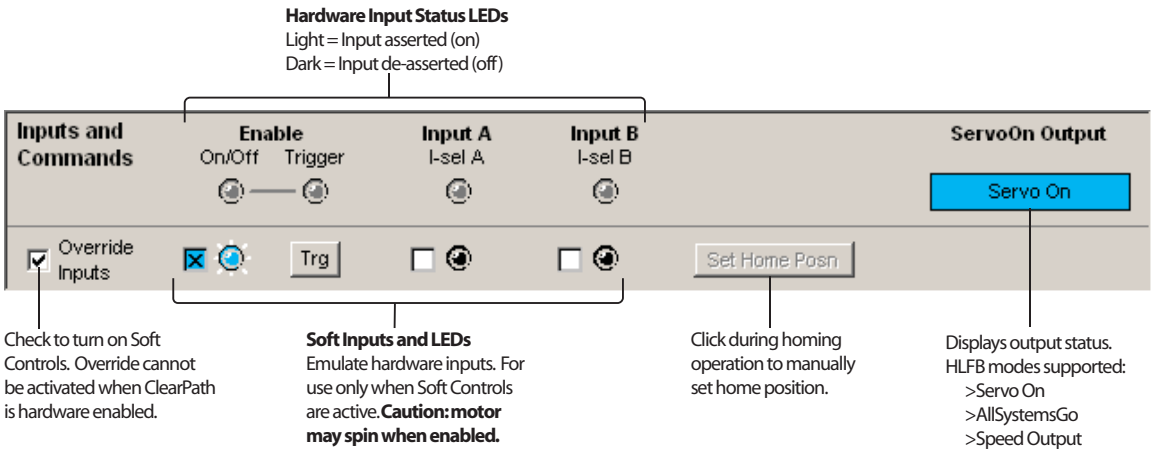
Incremental Position Mode: Inputs and Timing Diagram

Notes:

- A trigger pulse is required to launch each move. Move distance is selected with Input A and B.
- To create a longer continuous move, you can send multiple trigger pulses and ClearPath will automatically "chain" the move increments together to form a single non-stop move. Note: To successfully "chain" move increments, the burst of trigger pulses must be sent rapidly. The pulse train must be received by the ClearPath during the acceleration through constant velocity portion of move, *but not during the deceleration phase*.
- If a trigger pulse is received during the deceleration phase of a running move, it will not be chained to the original move. In fact, the "late pulse" will trigger a separate move.

MODE CONTROLS

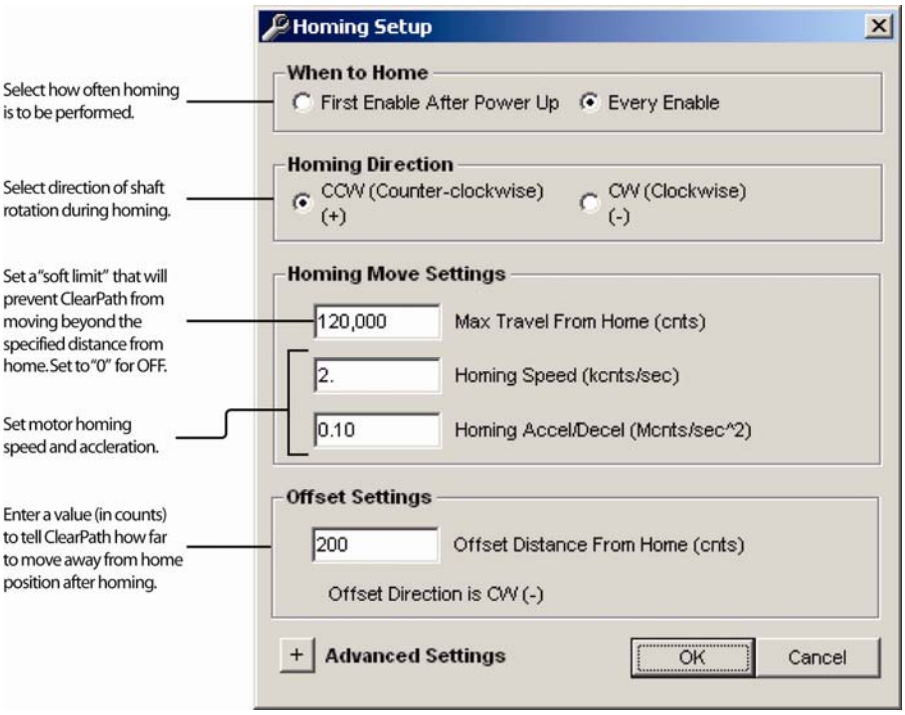




HOMING SETUP (HOME-TO-HARD STOP)

Homing is optional in this mode. Follow the instructions below to set up Hard Stop homing.

1. Install a hard stop that guarantees the moving element of the axis makes solid, repeatable contact with the stationary element when driven into it.
2. Enable homing in MSP.
3. Click the Setup button to open the homing dialog.
4. Enter homing parameters. See figure next page for description of homing parameters.



Homing setup dialog

5. Test and modify your homing setup for consistent, repeatable performance.

PULSE BURST POSITIONING

MODE SUMMARY

ClearPath will move a distance proportional to the number of pulses sent to Input B. This mode offers much of the flexibility of a "step-and-direction" system, without the need for an expensive indexer to create smooth move trajectories; that function is handled by ClearPath's internal trajectory generator. This mode is limited to two speeds and one acceleration/deceleration rate of the user's choice.

Note: A fairly simple PLC counter or a software loop can be used to generate pulses for use with this mode.

HOW IT WORKS

Assert the Enable Input to energize the motor. (Note: ClearPath can be configured to perform a homing routine upon enable.) To execute positioning moves, send a high speed stream of pulses to Input B, where each pulse represents a small, incremental unit of distance. Total move distance is determined by total number of pulses sent to Input B.

All moves are executed at the user-defined acceleration and speed setting. Direction of motor shaft rotation is controlled by Input A. See inputs and timing diagram below.

Trigger function: Alternate Speed

Briefly pulse the Enable input low, and the next pulse burst sent to ClearPath will result in a move at the alternate speed setting. Once that move is complete, ClearPath automatically returns to its default speed setting.

Pulse Positioning **Pulse Burst Positioning**

Signal	Function	Input Type	Example Timing
Input A	Direction Select	Logic: High=CW Low=CCW	
Input B	Pulse Input	Pulse: High-Speed Pulse Burst	
Enable Trigger	Enable Speed Select	Logic: High=Enable Low=Disable Pulse low to select alternate speed	
Notes: Maximum pulse input frequency = 500 kHz. Minimum pulse on/off time = 1uS.			v, alternate speed, t, *Motor velocity vs. time*

Trigger pulse

Pulse Burst Positioning Mode: Inputs and Timing Diagram

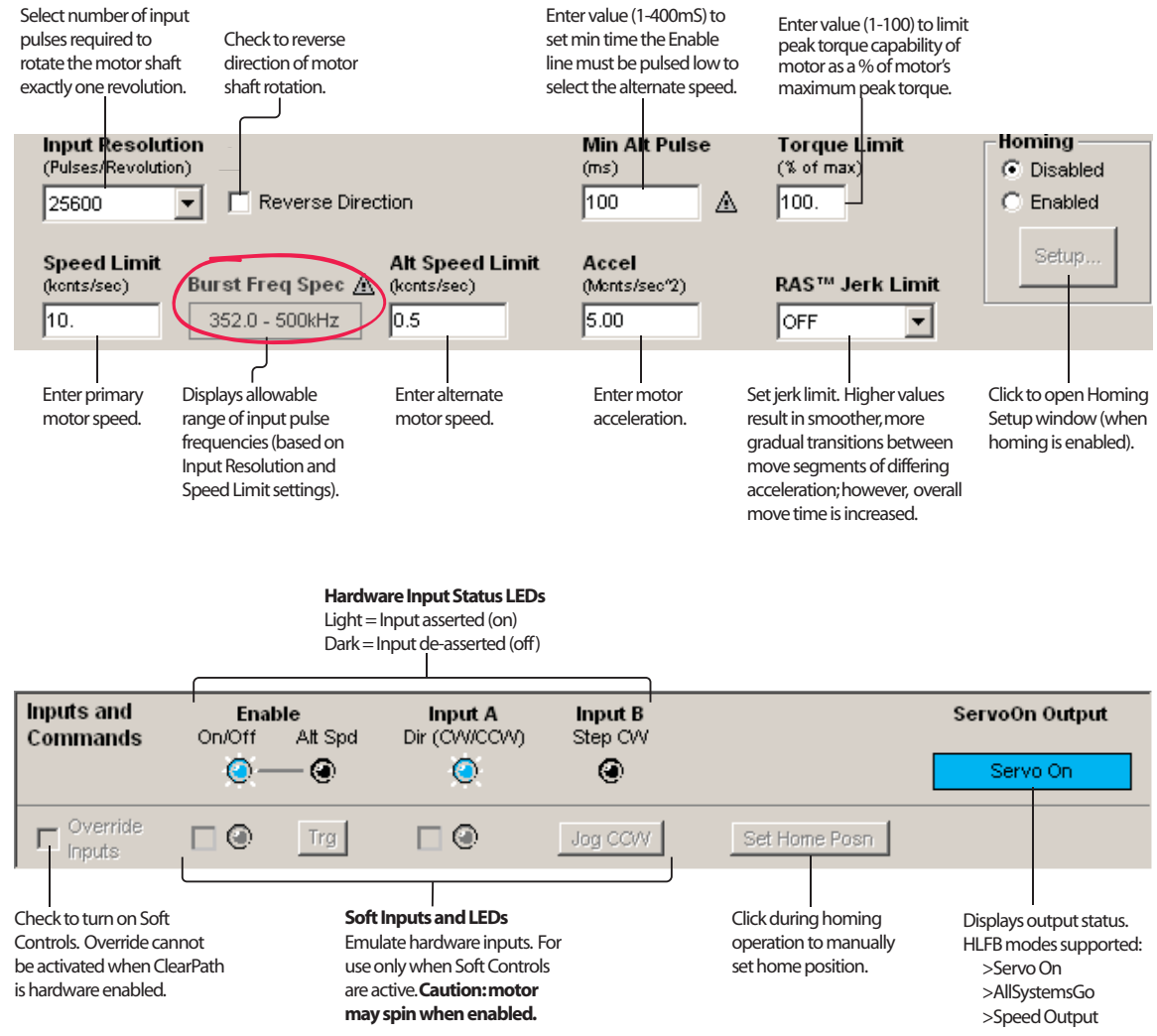
Notes:

- The frequency of the pulse train applied to Input B must always be higher than the specified speed limit(s). This ensures that the motor is never "consuming" pulses faster than they are being

supplied. See the "Burst Frequency Spec" (circled in red on the figure below) for the range of allowable pulse input frequencies.

- The pulse train can be of constant frequency, i.e. there is no need to ramp pulse frequency up or down as in a "step-and-direction" system. ClearPath automatically manages acceleration and deceleration profiles with its internal trajectory generator.

MODE CONTROLS

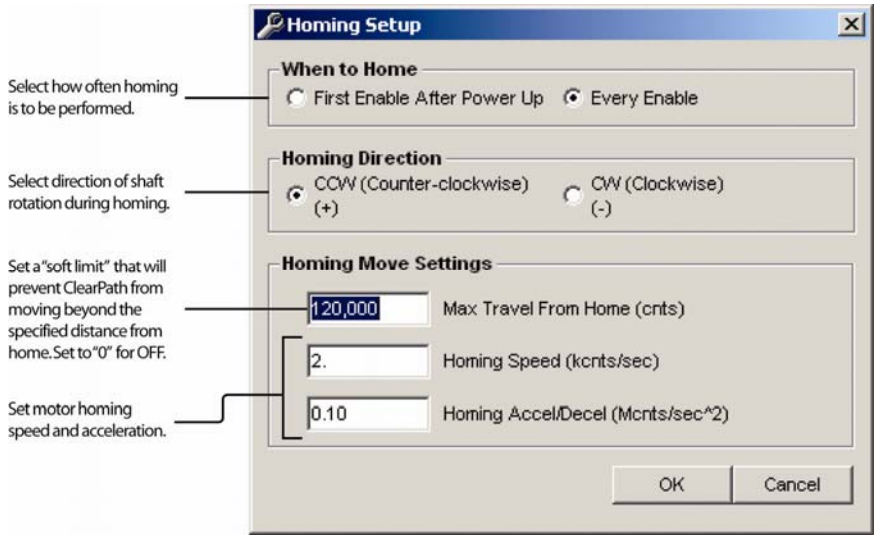


HOMING SETUP (HARD STOP HOMING)

In this mode, ClearPath can be configured to home to a hard stop to establish a home reference position before functional positioning begins.

1. Install a hard stop that guarantees the moving element of the axis makes solid, repeatable contact with the stationary element when driven into it.
2. Enable homing in MSP.

3. Click the Setup button to open the homing dialog.
4. Enter homing parameters. See figure below for description of homing parameters.



Homing setup dialog

5. Test and modify your homing setup for consistent, repeatable performance.

CLEARPATH SD (STEP AND DIRECTION)

The ClearPath SD family was designed to replace stepper motor/drive combos with a single, cost-effective unit. While all ClearPath SD models function in essentially the same way, there are differences in resolution and power between models within the family. See the Teknic/ClearPath website for complete information on SD Family ClearPaths.

STEP AND DIRECTION INPUT

MODE SUMMARY

You provide standard step and direction signals and ClearPath faithfully follows them. Use the included RAS (Regressive Auto Spline) feature to smooth the motion profile. This mode is great for replacing stepper motor and drive systems with one compact device that costs less and does more.

HOW IT WORKS

Assert the Enable Input to energize the motor. Then, supply standard step and direction pulses to Inputs A and B to command motion. This model requires step and direction signals from an external indexer, controller, or similar.

Stepper Replacement **Step and Direction Input Control**

Signal	Function	Input Type	Example Timing
Input A	Direction	Logic: High=CW Low=CCW	
Input B	Step	Pulse: Digital Step Input	
Enable	Enable	Logic: High=Enable Low=Disable	
Trigger	NA	NA	
Notes: Maximum pulse input frequency = 500 kHz. Minimum pulse on/off time = 1uS.			v t Motor velocity vs. time

Step and Direction Inputs and Timing

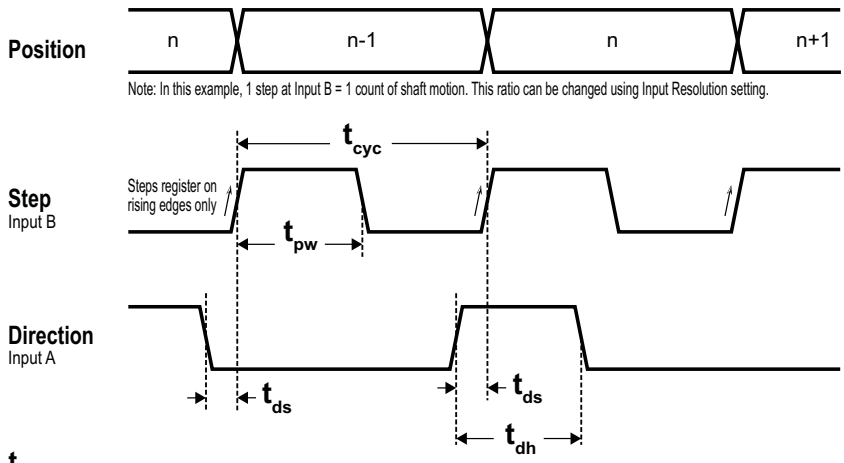
Notes:

- Maximum pulse input frequency = 500 kHz.
- Minimum pulse on/off time = 1uS. See diagram next page for important timing information.
- Motion occurs on the rising edge of each step input pulse.
- Time before Disable = 10 mS

STEP AND DIRECTION TIMING

The ClearPath Step Input is “positive edge-triggered”, so ClearPath registers a step only when Input B sees the rising edge of a step input pulse (i.e. an electrical transition from low to high). Refer to the diagram below for details and important step and direction signal timing requirements.

ClearPath can be configured to move one count for each step received, or one count per [x steps] received (based on the Input Resolution setting).



t_{pw} Minimum step pulse width = 1 uS

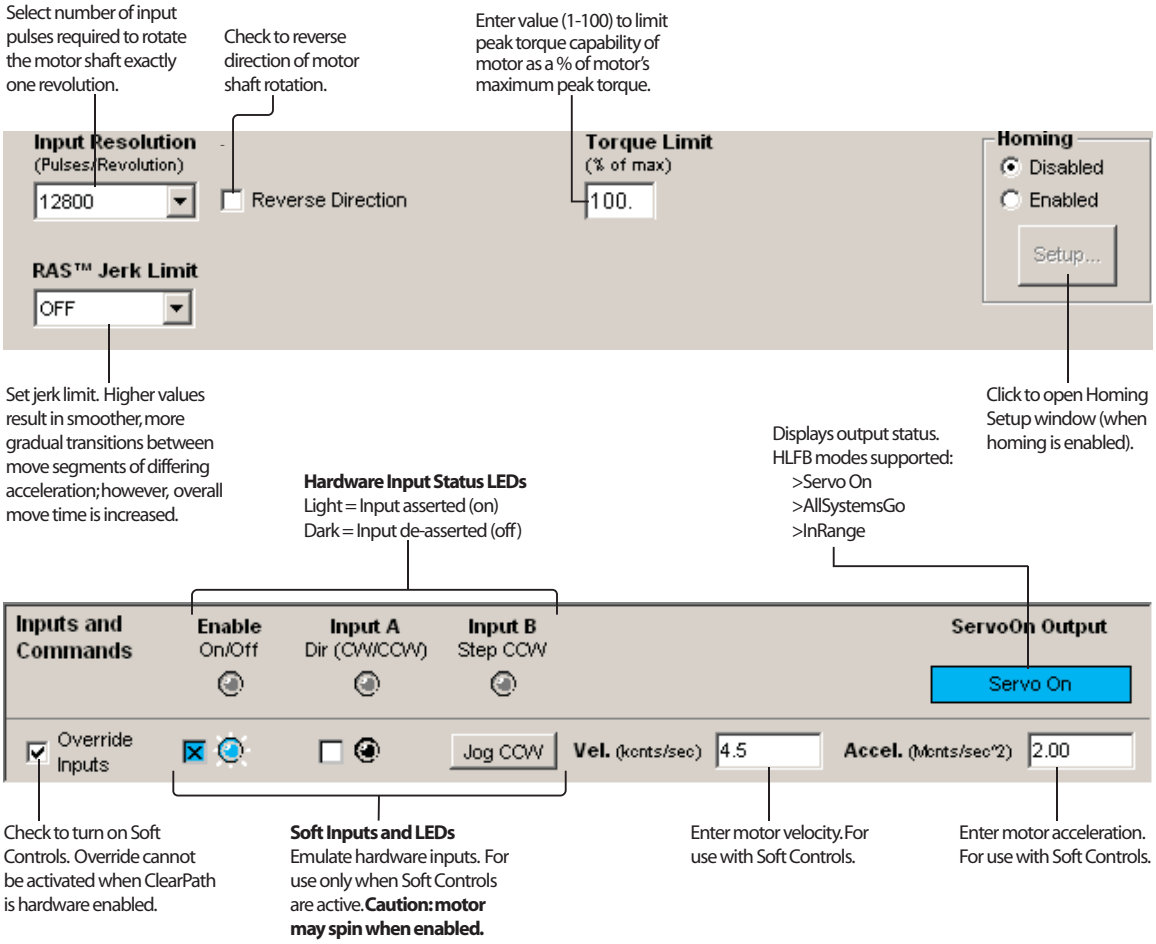
t_{cyc} Minimum step cycle time = 2uS

t_{ds} Minimum time between direction change and step input change = 25nS

t_{dh} Minimum direction hold time = 1uS

ClearPath minimum step and direction input timing diagram

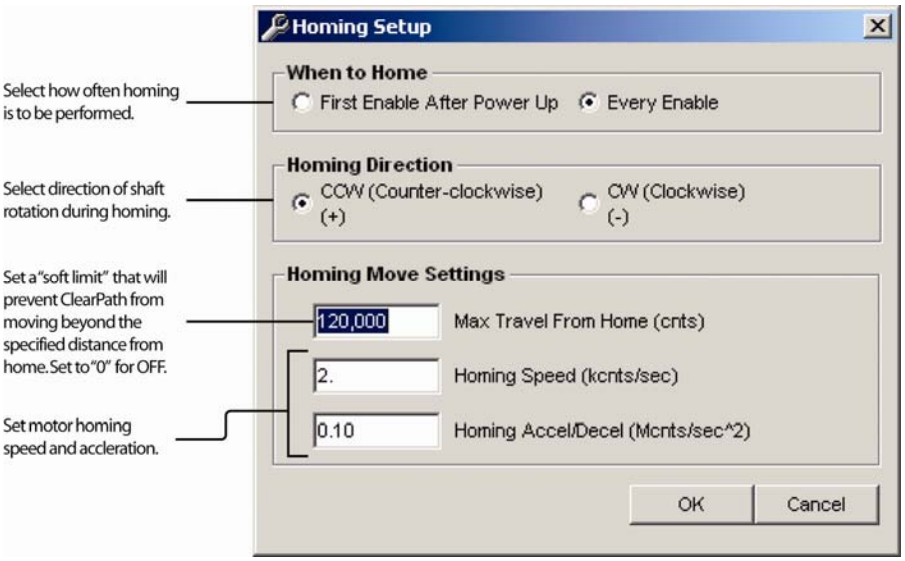
MODE CONTROLS



HOMING SETUP (HARD STOP HOMING)

In this mode, ClearPath can be configured to home to a hard stop to establish a home reference position before functional positioning begins.

1. Install a hard stop that guarantees the moving element of the axis makes solid, repeatable contact with the stationary element when driven into it.
2. Enable homing in MSP.
3. Click the Setup button to open the homing dialog.
4. Enter homing parameters. See figure next page for description of homing parameters.



Homing Setup dialog

5. Test and modify your homing setup for consistent, repeatable performance.

APPENDIX A: LED BLINK CODES

Note: In cases where multiple exceptions use the same blink code, you must connect ClearPath to a PC running MSP to determine exception type.

LED Behavior	Exception Type	Affect on Motion	Servo Behavior	How to Clear Exception	Status or Exception Message Reported in UI
No LED Activity *(See additional notes below table.)*	N/A	N/A	Servo off	N/A	**No (or Low) Power** Verify DC power is correctly wired and within specified voltage range (24-75VDC). Make sure main DC power never droops below 24VDC during motor operation.
Yellow – on solid	N/A	N/A	Servo off	N/A	**Status: Disabled** Motor power is turned off.
Yellow - flicker	N/A	N/A	Servo on	N/A	**Status: Performing commutation start-up**
Green - flicker	N/A	N/A	Servo on	N/A	**Status: Enabled** Motor power is on. ClearPath will respond to motion commands.
Yellow - 2 blinks	Shutdown	Disallows motion	Servo off	Toggle Enable input	**User Stop** ESC key or button was pressed by the user.
Yellow - 2 blinks	Shutdown	Disallows motion	Servo off	Toggle Enable input	**Motor Enable Conflict** The hardware inputs did not match the active software override inputs when the motor was enabled via the hardware enable line.
Yellow - 3 blinks	Shutdown	Disallows motion	Servo off	Toggle Enable input	**Max Bus Voltage Exceeded** Probable cause: high AC line voltage, large regenerated voltage upon deceleration.
Yellow - 4 blinks	Shutdown	Disallows motion	Servo off	Toggle Enable input	**Command Speed Too High** Probable cause: commanded speed/velocity is beyond motor spec.
Yellow - 4 blinks	Shutdown	Disallows motion	Servo off	Toggle Enable input	**Tracking Error Limit Exceeded** Possible causes: excessive friction, mechanical misalignment, vel/accel too high, low DC bus voltage.
Yellow - 4 blinks	Shutdown	Disallows motion	Servo off	Toggle Enable input	**RMS Torque Limit Exceeded** Possible causes: excessive friction, mechanical misalignment, duty cycle too high, undersized motor.
Yellow - 4 blinks	Shutdown	Disallows motion	Servo off	Toggle Enable input	**Excessive Bus Current** Probable cause: bad tuning, low bus voltage.
Yellow - 5 blinks	Shutdown	Disallows motion	Servo off	Toggle Enable input	**Excessive Motor Temp** Possible causes: ambient temperature too high for motor load; poor cooling; fan not running (if used).
Yellow – 6 blinks	Shutdown	Disallows motion	Servo off	Toggle Enable input	**Momentary Low Bus Voltage** Power supply drooped below 18V, insufficient current capabilities, and/impedance too high.
Yellow - 7 blinks	Shutdown	Disallows motion	Servo off	Toggle Enable input	**Old Config File Version** Probable cause: Firmware updated after config file was saved. Create or load new config file.
Yellow - 7 blinks	Shutdown	Disallows motion	Servo off	Toggle Enable input	**Motor Phase Overload** Phase current is beyond allowed ADC limit. Probable cause: incorrect tuning or wrong config file.
Yellow - 7 blinks	Shutdown	Disallows motion	Servo off	Toggle Enable input	**Hard Stop Gave Way** A mechanical hard stop was detected during homing but it gave way before homing was completed.

LED Behavior	Exception Type	Affect on Motion	Servo Behavior	How to Clear Exception	Status or Exception Message Reported in UI
Yellow - 7 blinks	Shutdown	Disallows motion	Servo off	Toggle Enable input	**Excessive Bus Current** Probable cause: bad tuning, low bus voltage.
Yellow - 7 blinks	Shutdown	Disallows motion	Servo off	Toggle Enable input	**Commutation Startup Error** DC bus too low for proper commutation start-up. Possible causes: brown out, incorrect power supply voltage, supply configured for higher AC line voltage.
Yellow - 7 blinks	Shutdown	Disallows motion	Servo off	Toggle Enable input	**Firmware ROMsum Error** Load config file compatible with motor's firmware version, or reset motor to factory defaults.
Yellow - strobe	Shutdown	Disallows motion	Servo off	Toggle Enable input	**Velocity Set Too High** Velocity/speed limit exceeds motor's factory-set maximum speed.
Yellow - strobe	Shutdown	Disallows motion	Servo off	Toggle Enable input	**RAS Change Rejected** Unexpected error. Contact Teknic for work-around or new firmware.
Yellow - strobe	Shutdown	Disallows motion	Servo off	Toggle Enable input	**Speed Too High For RAS** Unexpected error. Contact Teknic for work-around or new firmware.
Yellow - strobe	Shutdown	Disallows motion	Servo off	Toggle Enable input	**MagAlign Distance Error** Distance traveled does not match expected value. Possible cause: motor against an end stop, incorrect motor settings.
Yellow - strobe	Shutdown	Disallows motion	Servo off	Toggle Enable input	**MagAlign Direction Error** Direction traveled is incorrect. Probable cause: external forces during MagAlign procedure.
Yellow - strobe	Shutdown	Disallows motion	Servo off	Toggle Enable input	**DSP Watchdog Restart** Firmware problem. Re-flash firmware with same or newer firmware version. Return unit to Teknic if problem not solved.
Green/Yellow alternating	Lockdown	Disallows motion	Servo on	Toggle Enable input	**Travel Limits Violated (lockdown)** Commanded position is on the wrong side of the home position.
Green/Yellow alternating	Lockdown	Disallows motion	Servo on	Toggle Enable input	**Travel Limits Violated (lockdown)** Commanded position is beyond the Max Travel from Home position as specified in Homing Setup.
Green/Yellow alternating	Lockdown	Disallows motion	Servo on	Toggle Enable input	**Motor Enable Conflict** The hardware inputs did not match the active software override inputs when the motor was enabled via the hardware enable line.
Green – 2 blinks	Warning	Allows motion (if cause is no longer present)	Servo on	Auto-clears at start of next move if cause is no longer present	**Travel Limits Violated (warning)** Commanded position is on the wrong side of the home position.
Green – 2 blinks	Warning	Allows motion (if cause is no longer present)	Servo on	Auto-clears at start of next move if cause is no longer present	**Travel Limits Violated (warning)** Commanded position is beyond the Max Travel from Home position as specified in Homing Setup.
Green – 2 blinks	Warning	Allows motion (if cause is no longer present)	Servo on	Auto-clears at start of next move if cause is no longer present	**Move Buffer Underrun** Possible causes: move increments too small or sent too slowly.
Green - 3 blinks	Alert	Allows motion	Servo on	Auto-clears when cause is no longer present	**Torque Saturation** Power supply may be underpowered for application; Torque Limit may be set too low for command. Try lowering velocity and/or acceleration.

LED Behavior	Exception Type	Affect on Motion	Servo Behavior	How to Clear Exception	Status or Exception Message Reported in UI
Green - 3 blinks	Alert	Allows motion	Servo on	Auto-clears when cause is no longer present	**Voltage Saturation**
Green - 3 blinks	Alert	Allows motion	Servo on	Auto-clears when cause is no longer present	**Over Speed**
Green - 3 blinks	Alert	Allows motion	Servo on	Auto-clears when cause is no longer present	**Over Temp** Internal electronics >80 degrees C. Add fan.
Red - toggle	Motor Failure	Disallows Motion	Servo off	Not clearable	**Motor Has Failed** Return to Teknic for repair or replacement.

If ClearPath shows no LED activity

During operation, if ClearPath DC bus voltage droops below approximately 18VDC the following will occur:

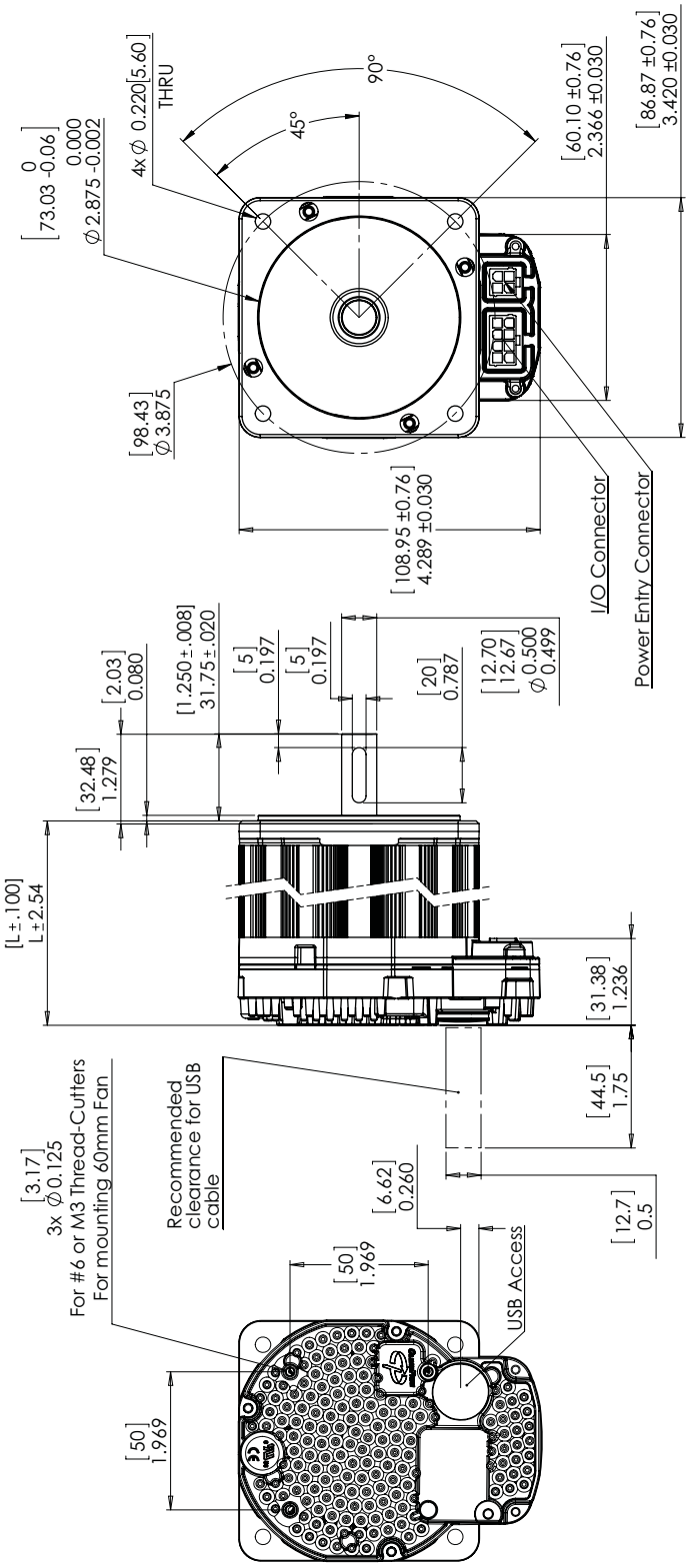
- ClearPath will go into shutdown state.
- The LEDs will turn off. Note: ClearPath will continue to communicate if voltage remains high enough.
- LEDs will remain off. Toggling the Enable *will not* clear the shutdown.

Once voltage returns to above approximately 20VDC:

- ClearPath will remain shutdown but LED will “wake up” and exhibit yellow blink code 6 (see table above for complete description of this exception code).
- Toggling the enable will clear the shutdown at this point.

APPENDIX B: MECHANICAL INSTALLATION

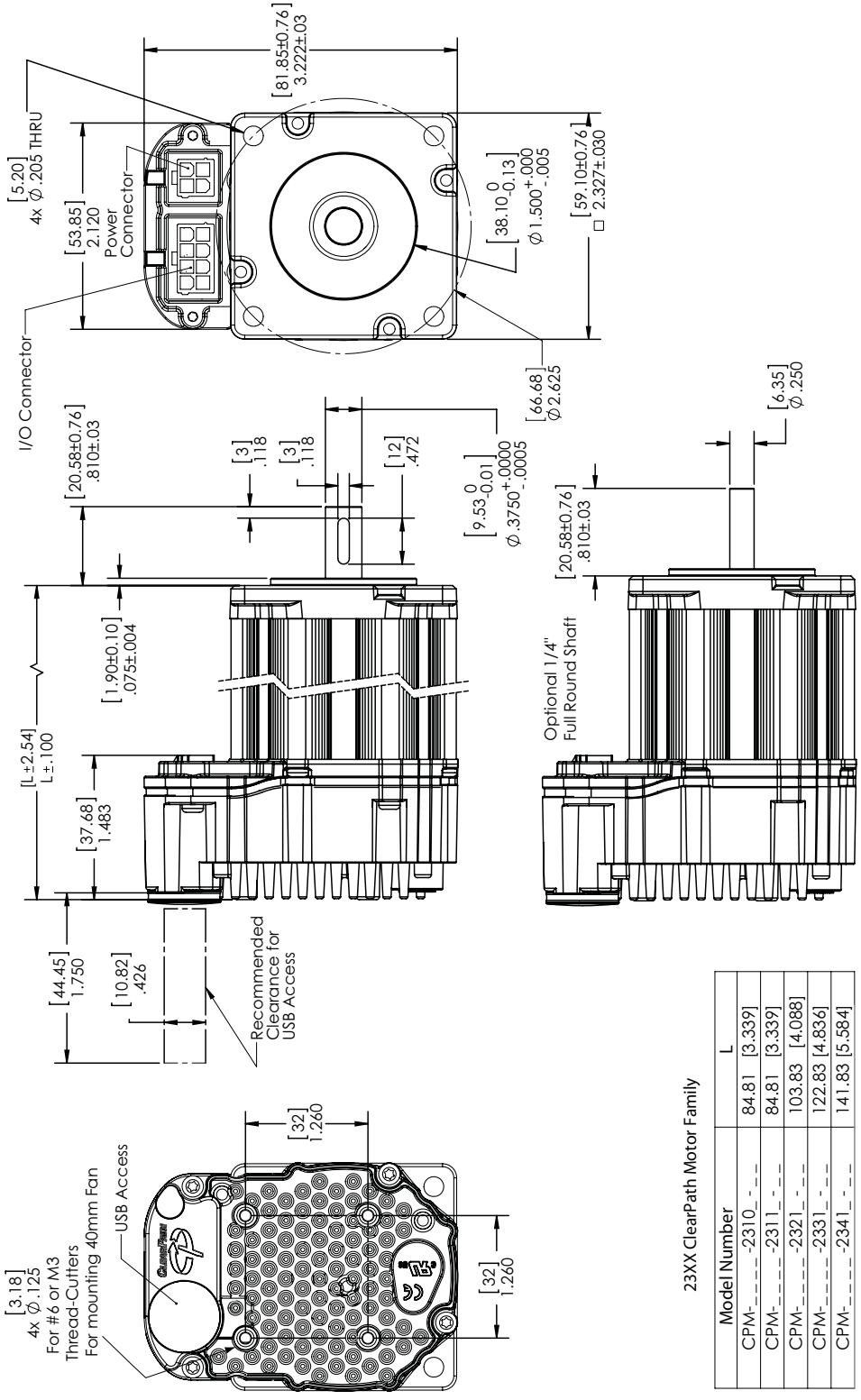
MOUNTING DIMENSIONS: CLEARPATH NEMA 34



34xx ClearPath Motor Family

Model Number	L
CPM-_ _ _ _ -3411_ - _ _	79.70 [3.138]
CPM-_ _ _ _ -3421_ - _ _	98.52 [3.879]
CPM-_ _ _ _ -3432_ - _ _	117.52 [4.627]
CPM-_ _ _ _ -3441_ - _ _	136.70 [5.382]

MOUNTING DIMENSIONS: CLEARPATH NEMA 23



23XX ClearPath Motor Family

Model Number	L
CPM-_ _ _ _-2310-_ _ _	84.81 [3.339]
CPM-_ _ _ _-2311-_ _ _	84.81 [3.339]
CPM-_ _ _ _-2321-_ _ _	103.83 [4.088]
CPM-_ _ _ _-2331-_ _ _	122.83 [4.836]
CPM-_ _ _ _-2341-_ _ _	141.83 [5.584]

MOUNTING CONSIDERATIONS

Tip: Teknic recommends mounting the motor such that the USB port and status LED are visible and accessible when the motor is mounted to the machine.

- Don't mount ClearPath over a heat source such as a power supply, spindle drive, etc.
- Don't mount ClearPath in an unventilated enclosure.
- Do allow for at least 1" of space all the way around each ClearPath.
- ClearPath can be fitted with an external accessory fan if desired.
- ClearPath will perform a protective Shutdown when its internal temperature sensor threshold is exceeded.

CONNECTING CLEARPATH TO A MECHANICAL SYSTEM

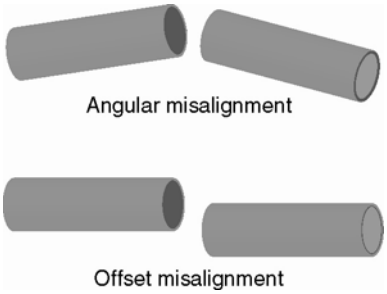
While it's obvious that ClearPath must be connected to a mechanical system to do useful work, it's not always clear just how to connect the motor to the mechanics.

Problems arise when a connecting element (such as a coupling) slips, exhibits excessive backlash, or can not accommodate typical shaft-to-shaft misalignments. Ultimately, the choice of shaft interface or coupling depends on the application, whether a precision positioning stage or a low speed conveyor.

The shaft interface (coupling, pulley, pinion, etc.) must be securely clamped to the shaft with minimum backlash (ideally none). This primary mechanical interface is critical in achieving and maintaining the best possible performance from a servo motion system.

MOTOR CONNECTION: GENERAL TIPS AND GUIDELINES

- **Align with care.** When connecting two shafts, such as a motor shaft to a ball screw shaft, the rotating centers must be carefully aligned in both the angular and offset sense to achieve the best possible motion quality and longest motor/bearing life.



Some couplings are more forgiving of misalignment than others, but in general, misalignment can cause undesired vibration/noise, shortened bearing life, and even broken motor

shafts. For a white paper on the topic of shaft alignment, click here.

- **Use lightweight components.** Aluminum couplings, pinions, and pulleys add significantly less inertia to the motion system than steel parts of the same size. In most applications, lower inertia is preferable because it allows the motor (and attached mechanics) to accelerate harder and move and settle faster.
- **Avoid using set screws.** Coupling devices with set screws are prone to failure and often become the weak link when joining a motor to a load. Set screws deform the metal around the screw's point of contact, often resulting in a raised bur on the shaft that can make it hard to remove and replace the coupling element. Set screws also tend to slip and score the shaft.
- **Tip:** Couplings, pulleys and pinions with circumferential clamping mechanisms tend not to damage motor shaft, hold better, and are easier to replace than those that use set screws.
- **Clamp close to the motor.** For maximum performance, secure pulleys and pinions as close to the motor face as practical. This effectively reduces the lever arm (and associated bearing load) for applications with a side load.
- **Don't over tighten belts.** Always read the belt manufacturer's guidelines for proper belt tension, but never exceed the ClearPath specification for maximum side load. Overly tight belts put undue stress on the motor shaft and bearing systems that can result in premature bearing and shaft failure.
- **Avoid using shaft keys when possible.** Although the ClearPath includes a keyway feature on the shaft, Teknic does not generally recommend the use of keys. Keys tend to cause run-out and backlash errors, particularly in reciprocating, precision positioning motion applications.
- **Note:** Keys *should be* considered for use in applications where coupling slip could result in a dangerous or hazardous condition. Also, key use may be appropriate for unidirectional applications (where the motor always spins in the same direction) as these applications are less prone to key-related lash problems.
- **Avoid direct loads.** In general, ClearPath motors are not designed for connection to direct loads (direct connection to a grinding wheel for example). However, direct connection may make sense if the load is of low-mass and balanced, as with small mirrors for laser applications.

NOTES ON COUPLING SELECTION

A complete coverage of the topic *Coupling Selection for Servo Applications* is beyond the scope of this document, but many articles and resources can be found on the web for those interested in learning more. Because there are so many different coupling styles and applications, selecting the "right" coupling for a particular application can be challenging.

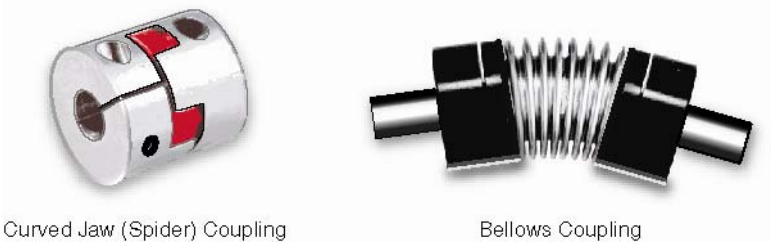
General Guidelines for Coupling Selection

Teknic has a few guiding principles when it comes to coupling selection for servo applications. Keep in mind that these are rules of thumb and may not apply to every application. In general:

- **Don't** undersize the coupling. Understand how much torque your application requires and stay within the coupling manufacturers specifications. Always leave reasonable engineering margin.
- **Don't** use set screw type couplings. They damage the motor shaft and tend to be less reliable over time than clamp style couplings.
- **Do** use clamp style couplings. These clamp around the circumference of the shaft at one or two points without deforming the shaft surface.
- **Don't** use rigid couplings—they are notoriously intolerant of misalignments.
- **Don't** use beam style (helical) couplings if vibration damping or torsional stiffness is critical to your application. Beam couplings tend to resonate/whine at higher speeds.
- **Don't** use any coupling that requires you to drill into, deform, or "pin" the motor shaft.

Coupling Recommendation

Teknic often recommends **zero-backlash curved jaw couplings** (commonly referred to as "spider couplings") as a good choice for many servo applications. These couplings are moderately priced and widely available from well established manufacturers such as Ruland.



Couplings for servo applications

Note: Curved jaw couplings (also known as spider couplings) are a good choice for many applications, but cannot tolerate a great deal of misalignment or axial motion. Also, never exceed the manufacturer's rating for "maximum torque with zero backlash" when using jaw couplings.

Bellows couplings are also excellent for high precision positioning applications. Bellows couplings allow for more misalignment than jaw couplings but are generally more expensive.

Both curved jaw and bellows coupling offer excellent positioning accuracy, high speed performance, and vibration damping when installed and operated within the manufacturer's specifications and guidelines.

Coupling Information on the Web

Ruland's website has a good collection of technical information on coupling types and coupling selection for servo systems. Click here for access to technical articles, videos, and CAD drawings. Or go to http://www.ruland.com/a_articles.asp.

INSTALLING PULLEYS AND PINIONS

PULLEY AND PINION MOUNTING

- Always follow the manufacturers mounting guidelines.
- Mount pulleys and pinions as close to the motor face as possible.
- Never drill through, "pin", or deform the motor shaft when mounting a pulley or pinion.

Application Tip: To prevent loosening/slip, some users bond their pulleys and pinions to the motor shaft with a high strength adhesive such as Loctite #638. While this is very effective in preventing pulley slip, it can be difficult to undo once the adhesive has cured.

END-OF-TRAVEL STOPS

End-of-travel stops are typically installed to prevent the moving element of a linear axis from flying off the machine in the event of a use or control error. There are a few common types of end stop to consider, but the final choice depends on the application objectives and requirements.

HARD BLOCKS

This is usually a solid block of steel, aluminum, or hard plastic secured at one or both ends of travel and positioned in such a way as to make even, repeatable contact with a hard surface on the moving element. Hard blocks are very effective at arresting motion, but can result in mechanical damage when struck at high speeds.

In several modes, ClearPath must home to a hard stop to establish a home reference position before functional positioning can begin.

ELASTOMERIC (RUBBER) STOPS

High durometer rubber stops (hard rubber) can also be used with applications that use HardStop Homing. This type of end stop offers a higher level of shock absorption and axis protection than hard blocks. Spongy, low durometer rubber stops are not recommended in most cases. They offer little benefit over a hard end stop during an axis crash.

PNEUMATIC (DASHPOTS)

Pneumatic hard stops (dashpots) offer excellent shock absorption performance but are considerably more expensive than hard blocks. Examples of specialized dashpots include the hydraulic cylinder in an automobile shock absorber as well as many automatic door closers.

END STOPS AND HARD STOP HOMING

End stops from medium durometer rubber to steel can be used successfully with Hard Stop Homing. When selecting end stops for a Hard Stop Homing application consider the following:

- Axes with low friction that are easily back driven can tolerate “softer” rubber end stops and still achieve good homing performance.
- Higher friction applications and those that cannot be back driven will generally require harder end stop material to achieve best Hard Stop Homing performance.
- Be prepared to test and experiment with different end block materials to ensure proper homing operation with your mechanical system.

FAN MOUNTING AND COOLING

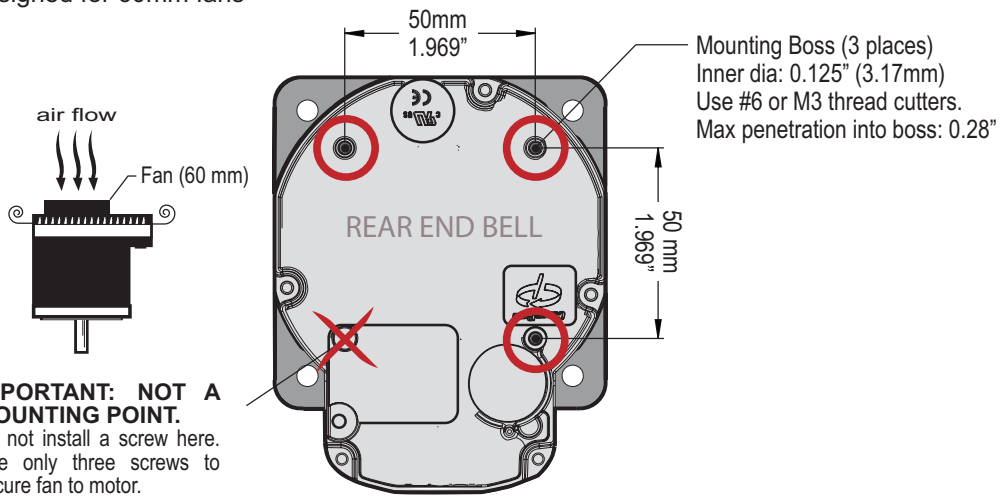
All ClearPath motors have unthreaded mounting bosses on the rear casting to accommodate a standard DC fan (60mm for NEMA 34 motors, or 40mm for NEMA23 size motors). See the diagram below for mounting dimensions, hardware and supported fan sizes. Teknic does not sell accessory fans, but they are readily available through electronics suppliers including Digikey and Mouser.

Note: As with all electronic products, *cooler is better* for longest life span. So, even though ClearPath can reliably operate at elevated temperatures (exceeding the ratings of most motor drives) your system should always be designed with the best cooling you can reasonably provide.

Note: ClearPath will shut down to self-protect when the rear cover temperature reaches 80 degrees C.

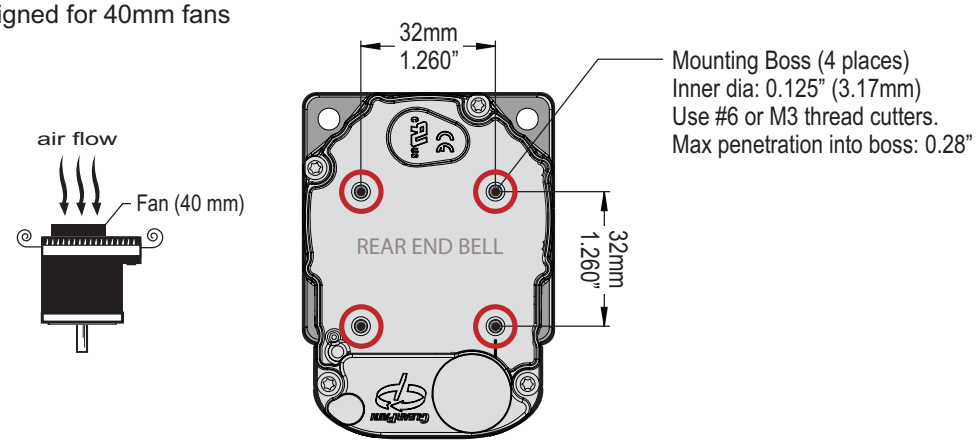
ClearPath NEMA 34

Designed for 60mm fans



ClearPath NEMA 23

Designed for 40mm fans

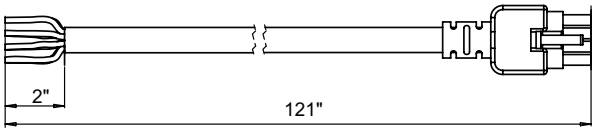


APPENDIX C: CLEARPATH CABLE PINOUTS

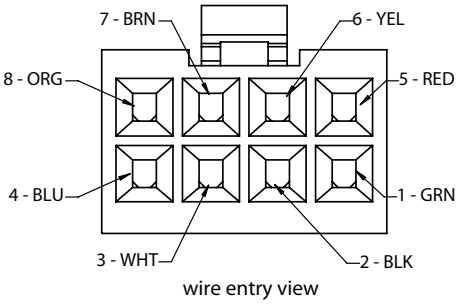
This section contains pinout information for ClearPath accessory cables available through Teknic and Teknic distribution.

CPM-CABLE-CTRL-MU120

Cable description: ClearPath I/O connector cable. Molex MiniFit Jr. 8-position connector to flying leads.

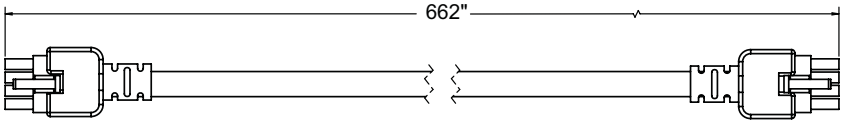


Pin Assignments		
Pin	**Color**	**Name**
1	GRN	HLFB +
2	BLK	Input B +
3	WHT	Input A +
4	BLU	Enable +
5	RED	HLFB -
6	YEL	Input B -
7	BRN	Input A -
8	ORN	Enable -

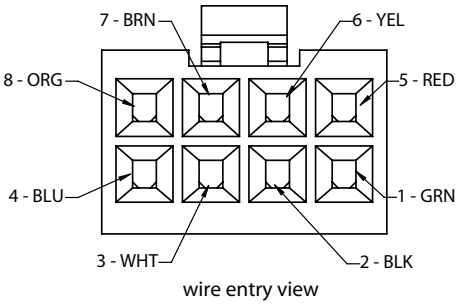


CPM-CABLE-CTRL-MM660

Cable description: ClearPath I/O connector cable (double-ended). Molex MiniFit Jr. 8-position connector to same. Use “as is” or cut in half to make two cables with flying leads.

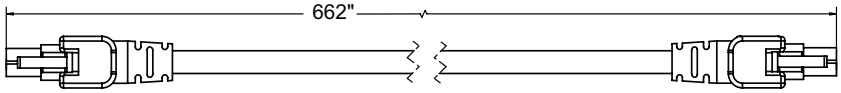


Pin Assignments		
Pin	**Color**	**Name**
1	GRN	HLFB +
2	BLK	Input B +
3	WHT	Input A +
4	BLU	Enable +
5	RED	HLFB -
6	YEL	Input B -
7	BRN	Input A -
8	ORN	Enable -

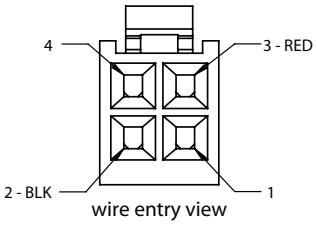


CPM-CABLE-PWR-MM660

Cable description: ClearPath power cable (double-ended). MiniFit Jr. 4-position connector to same. Use “as is” or cut in half to make two cables with flying leads.

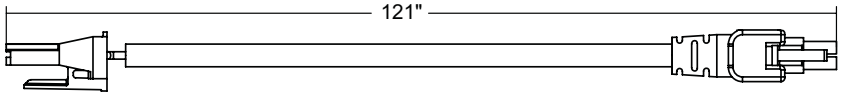


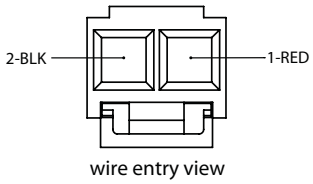
Pin Assignments		
Pin	**Color**	**Name**
2	BLK	GND
3	RED	V+

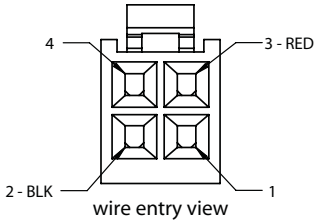


CPM-CABLE-PWR-MS120

Cable description: ClearPath power cable. This cable connects the DC output of a Teknic E3PS12-75 power supply to the ClearPath power input connector. It features a Sabre 2-position connector to Molex MiniFit Jr. 4-position connector.







Pin Assignments		
Pin	**Color**	**Name**
1	RED	V+
2	BLK	GND

Pin Assignments		
Pin	**Color**	**Name**
2	BLK	GND
3	RED	V+

APPENDIX D: COMMON SPECIFICATIONS

Electrical Power Requirements:	
Supply Voltage, Typical:	24VDC to 75VDC
Supply Voltage, Minimum	21VDC (measured at input terminals)
Supply Voltage, Maximum:	90VDC (measured at input terminals)
Continuous Bus Current, Typical:	1A to 4A (application dependent)
Continuous Bus Current, Maximum:	10A
Idle Power usage from Bus	4W (enabled, no torque used by axis or load)
	3W (disabled)
Electrical I/O:	
Logic Input Voltage Range:	4.0VDC to 28VDC
Input Current @ 5V:	7.5mA (maximum)
Input Current @ 28V:	12.0mA (maximum)
HLFB Absolute Maximum Voltage	30VDC (across output terminals)
HLFB Output Current, Maximum:	5mA (non-inductive load)
HLFB Reverse Current, Maximum:	100mA
HLFB Output voltage drop @ 2mA:	0.50VDC
HLFB Output voltage drop @ 5mA:	0.90VDC
Motor Bearing, NEMA34:	
Maximum Radial Load, NEMA34:	220N (50-lbs), applied 25mm (1.0in) from front bearing
Maximum Thrust Load, NEMA34:	44N (10-lbs)
Bearing Life, NEMA34:	2.4×10^9 to 5.3×10^9 revs (typ., load dependent.)
Motor Bearing, NEMA23:	
Maximum Radial Load, NEMA23:	110N (25 lbs), applied 25mm (1.0in) from front bearing
Maximum Thrust Load, NEMA23:	22N (5 lbs)
Bearing Life, NEMA23:	3.2×10^9 to 5.0×10^9 revs (typ., load dependent.)
Environmental:	
Shock (peak, maximum):	10G (applied no more than twice)
Vibration (RMS, 2 Hz-200 Hz):	1.0G or 0.5mm, whichever is less
Maximum External Shaft Deceleration:	250,000 rad/s^2
Maximum Ambient Operating Temp.:	For seasonal/intermittent duty: 70°C/158°F (RMS torque output de-rated)
	For continuous long-term use: 55°C/122°F (RMS torque output de-rated)
	For full-rated output speed/torque: 40°C/104°F
Maximum Body Temp.:	100°C
Maximum Rear Cover Temp.:	70°C
Storage Temperature:	-20°C to 85°C
Humidity:	0% to 90%, Non-Condensing
Recommended Optional Fan, NEMA23:	40mm square, 45.25 mm bolt center, >7CFM
Recommended Optional Fan, NEMA34:	60mm square, 70.71 mm bolt center, >14CFM
Environmental Sealing:	
Front Face, with shaft seal option:	IPC 65
Front Face, w/o shaft seal option:	IPC 53
Body/rear, with dielectric	IPC 55
sealing grease in connectors	
Body/rear, naked	IPC 53
Compliance:	
Regulatory Certifications:	UL recognized, CE, RoHS
Electrical Safety:	UL508C, (EN 61010-1 pending)
EMI:	EN 61326-1 (pending)
Country of Origin:	USA
Warranty:	3 years

Teknic Incorporated
1150-E Pittsford-Victor Road
Pittsford, NY 14534